FINAL REPORT

WATER RESOURCES ASSESSMENT PROJECT

A survey of current and projected future water uses in the state with analysis of water supply and demand trends and their economic implications on Montana's future.

DNRC

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

WATER RESOURSES DIVISION — AUGUST 1981

WATER RESOURCES ASSESSMENT PROJECT

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DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA
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This document is a reissue of a report that was originally released in 1978.

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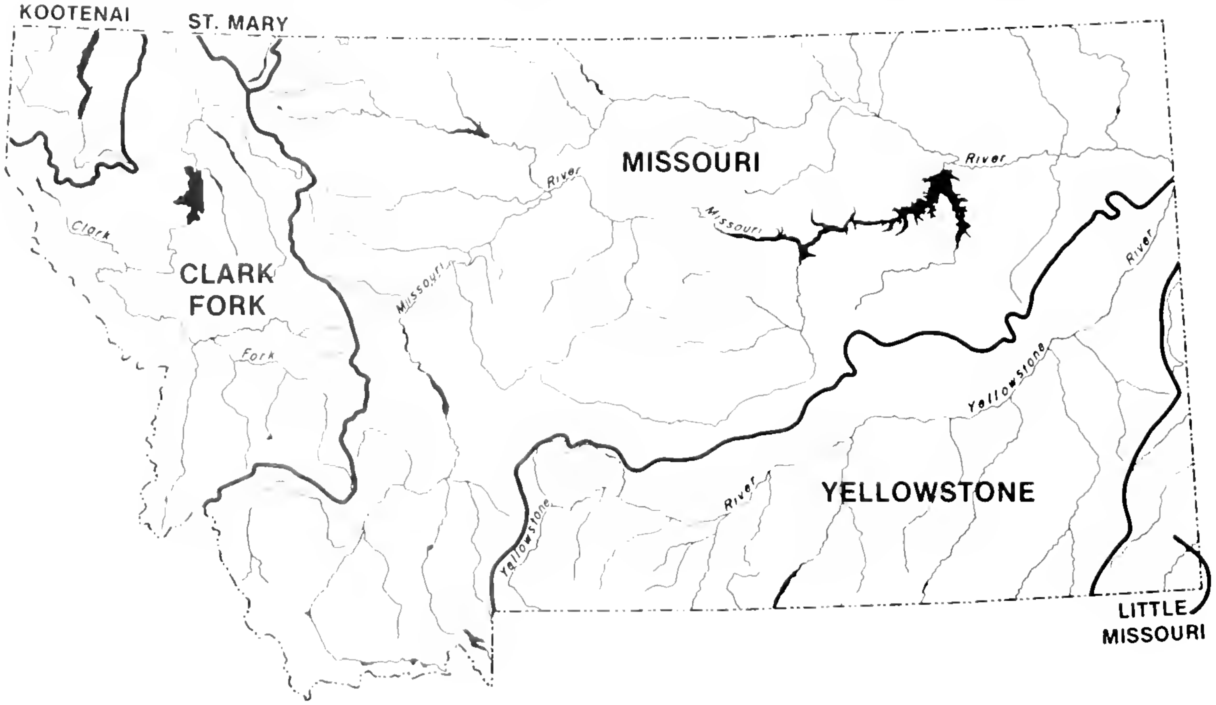

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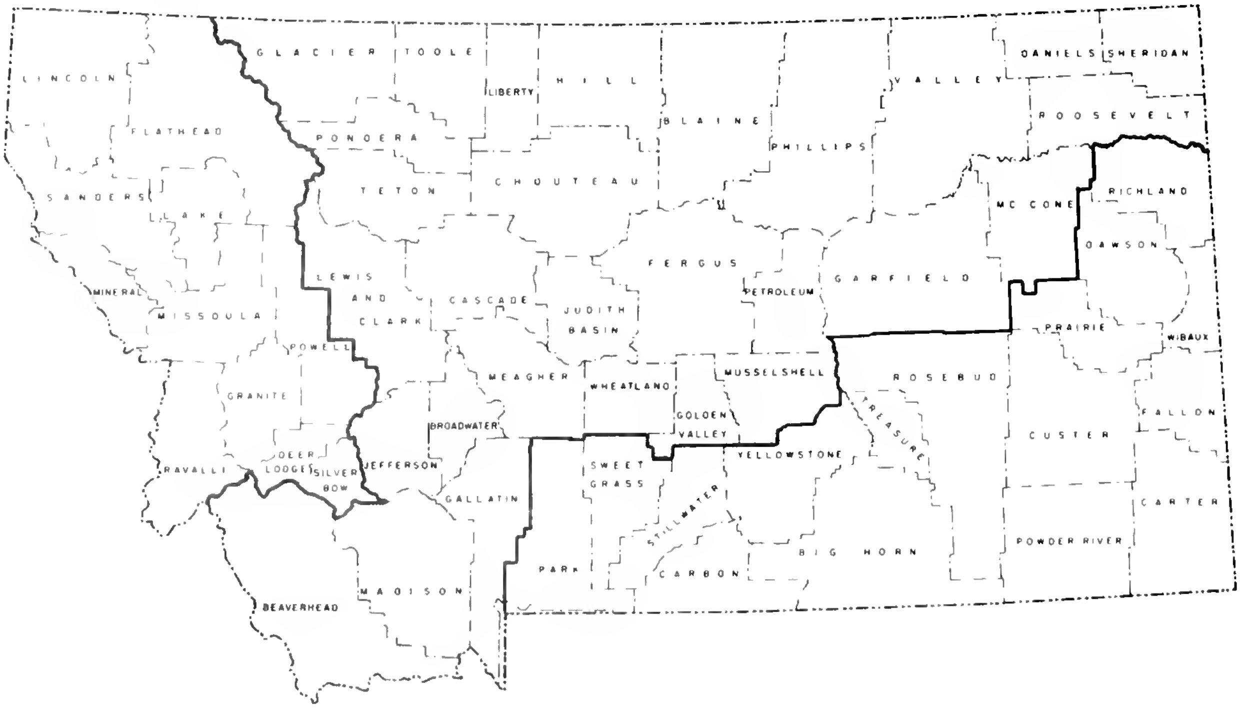

FIGURE 1. DRAINAGE BASIN BOUNDARIES

I. INTRODUCTION

This report was completed by the Montana Department of Natural Resources and Conservation under contract with the Governor's Employment and Training Council, Department of Labor and Industry. The purpose of the report is to provide an analysis of water supply and demand trends and projections and their potential effect on Montana's economic future. The report is authorized by the Comprehensive Employment and Training Act of 1973.

II. WATER DEMAND

Uses of water can be classified as instream uses and uses which require withdrawal or diversion from the stream. Withdrawal uses usually consume quantities of water less than the amounts diverted. Instream uses include the generation of hydroelectric power, waste disposal, recreation, preservation of fisheries and the riparian habitat, and water quality maintenance. Withdrawal uses include irrigation, municipal, and industrial use.

The quantity of water available for competing uses is limited by precipitation and natural streamflow. The basic question is how to allocate flow to the different uses. The optimal economic solution will consider the value of water in alternative uses as the basic allocative criterion. This requires estimates of the value of water in alternative uses. However, all of the uses of water in a river basin are interdependent; one activity at a given location can result in losses in opportunities and/or indirect benefits to other users. For example, the diversion of water for irrigation precludes its downstream use for hydropower generation. The presence of interdependencies among alternative uses greatly complicates the valuation of alternative uses of water.

The demand for water is derived from the willingness of users to pay for its use. Where water is used for agricultural and industrial purposes, demand arises from the contribution that water makes toward the production of final goods and services, i.e. its marginal productivity. The basis for willingness to pay for irrigation water comes from the net increase in income a farmer receives from the land made productive by irrigation. Willingness to pay for water as an input in energy production and other industrial uses is limited by the additional cost of alternative technologies to produce the same outputs.

AGRICULTURAL DEMAND

Both the supply and demand for agricultural products determine the feasibility of irrigation development. At higher prices producers are willing to supply more on the market, while the quantity demanded by consumers decreases as prices rise. The interaction of supply and demand determines the price level in a market. The price, or value, of agricultural products indirectly determines the value of water for irrigation via its marginal productivity. Population, incomes, farming costs, climate, soils, topography, and other factors also affect the value of irrigation water.

The value of irrigation water is derived from the increased profits made possible through increased yields and altered cropping patterns. Part of the water required for a crop to achieve maximum yield is supplied by precipitation. Irrigation provides a supplementary moisture source when precipitation is insufficient. The optimal quantity of irrigation water depletions is the quantity where the value of marginal product equals the cost of increased irrigation.

In general, the marginal costs faced by irrigators are less than the opportunity cost of the water to society. This is partly because all federal irrigation projects are subsidized by the Bureau of Reclamation and the Soil Conservation Service. The DNRC also subsidizes state-owned irrigation projects. In addition the price of irrigation water at the source is zero while its instream value or opportunity cost is not zero. Thus for the individual farmer the optimal rate of water withdrawal is seldom the optimal social rate of irrigation water use.

The quantity of water demanded by each farmer is inversely related to the price of water. The aggregate demand for irrigation water is the sum of the quantities that would be purchased by all irrigators.

Irrigated acreage in Montana has been increasing over the last few years, reversing a long-term downward trend. About 2/3 of all new irrigation projects are sprinkler systems with pump lifts varying from a few feet to over 400 feet above the water source. Future expansions will be affected by crop yields, crop prices, costs of production, and the effects of increased output on market prices. Much of the irrigated cropland in Montana is utilized for beef production. The market for beef is highly variable and is affected by several factors, among them: general economic conditions, federal import/export policies, world eating habits, farmer preferences and peer influence, and the availability of an adequate land base in proximity to water supplies.

Over 95 percent of the water withdrawn from Montana drainages is used for irrigation. Approximately 47 percent of the waters diverted for irrigation purposes are depleted and are unavailable for downstream uses. Of the remaining water withdrawn for all other uses only one-fourth, or approximately 1 percent of the total, is consumed.[1] Irrigation is by far the largest consumptive use of water in Montana.

MUNICIPAL AND INDUSTRIAL DEMAND

Factors that affect the demand for municipal water uses include metering, water rates, water quality, extent of sewage system, management practices of the water works, population, and standards of living.

Public water supplies served approximately 72 percent of the state's population in 1970. Total municipal and industrial use in that year was estimated at 149,000 acre-feet per year (the unit most commonly used to measure volume) or 1.33.1 million gallons per day, which amounts to 1.1 percent of all water withdrawn in the state. Of that amount, industry used 38 percent.

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[1] Montana Department of Natural Resources and Conservation, Water Use in Montana: Inventory Series Report No. 13, April 1975: pp. 4-13.

While residential users consumed approximately 50 percent of the water used, industry consumed only 15 percent. Water use ranged from 42 to 1,169 gallons per capita day (gpcd), with the statewide average being 267 gpcd.[2]

Future water use may be predicted as the product of projected community population and per capita use, based on current use patterns. The city can determine its current use per capita, make adjustments for expected changes in local demand, and multiply by projected population to estimate water requirements for a series of future dates. This common approach fails to recognize that use per capita is inversely related to price and that current use per capita is an inadequate estimate of future use rates if municipal water prices change. The price elasticity of demand for residential water has been found to be about -0.35.[3] Howe and Linaweaver found the price elasticity for domestic (household) water to be -0.23 and for sprinkling demand to be -0.7 in arid areas.[4] This means that a 10 percent increase in the price of water for sprinkling will decrease sprinkling demand seven percent.

One factor that influences municipal water costs is water quality standards, as they affect both drinking water within the system and effluent discharges. More stringent standards increase the costs of treatment before use as well as the costs of sewage treatment and disposal.

One means of meeting the higher costs is to increase (or implement) user charges for municipal water. Not only will more funds be available for sewage treatment and disposal, but users will be induced by the higher water bills to use less water. A larger portion of this conservation is likely to be in water for sprinkler demand since 50 percent of municipal water in Montana is consumed in lawn sprinkling; the demand for sprinkling water is much more price-responsive than the demand for domestic water. However, the Public Service Commission regulates municipal water rates, and it is likely that bureaucratic rules and procedures would prohibit timely pricing strategies on a municipality's own initiative.

ENERGY INDUSTRY WATER USE DEMAND

Most of the water used by the coal industry for on site energy production is used for cooling. There are basically three alternative cooling technologies for this process: once-through cooling, wet-cooling towers, and dry-cooling towers.

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[2] Montana Department of Natural Resources and Conservation, Water Use in Montana: Inventory Series Report No. 13, April 1975: pp. 13-16.

[3] John Ernest Flack, "Water Rights Transfers: An Engineering Approach" (Standford, California: Stanford University, Institute of Engineering Economic Systems (EEEP-15, 1965), pp. 49-63, cited by L. Douglas James and Robert R. Lee, Economics of Water Resource Planning, p. 315, 1971, McGraw-Hill.

[4] Cited in James and Lee, p. 315: Charles W. Howe and F.B. Linaweaver, Jr., "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure," Water Resources Research, Vol. 3, 1st Qtr. 1976: pp. 13-32.

Once-through cooling is the most water intensive method of heat dissipation. The process simply diverts water from a source, transfers the heat from the plant process to the water, and returns the water to its source. Though very little water is consumed, large amounts must be diverted from the source. These plants have a low value per unit of water and a strong dependency on proximity to large and dependable streamflows.

In wet cooling towers, from .6 to .84 gallons of water per kilowatt hour of production is consumed by evaporation and drift. Fresh water must be continually added to replace the water lost and maintain an acceptable level of concentration of dissolved solids. The evaporating water removes heat from the remaining water, and some cooling is accomplished by increasing the temperature of the air passing through the tower.

Dry towers use air to cool the water without evaporation. Thus the same water can be reused continuously. Initial on-site capital costs for dry towers are higher than for wet towers, and operating and maintenance costs are also higher. However, costs may be reduced somewhat by placing plants near the coal mines without regard to the availability of large quantities of water.

Demand for water in thermo-electric processes arises from the additional cost of producing the same amount of electricity by the least-cost alternative technology. This will vary according to location of the plant site, the state-of-the-art in electrical generation technologies, and the market for electrical energy.

Stroup and Townsend (1974) estimated that the value of water for thermal-electric generation ranges from $106 to $197 per acre foot, delivered, depending on fuel costs, interest rates, and other assumptions. Harza Engineering Company (1976) estimated that dry cooling becomes economical for base load plants at a delivered cost of $450 per acre-foot and for intermediate load plants at $750 per acre-foot.

HYDROPOWER

Hydroelectric power genration is a major instream use for water in Montana. The demand for water passing through these turbines is again derived from the market for electricity. None of the water used is consumed, though reservoirs must be kept at certain levels for turbines to operate at maximum capacity. This affects the availability of water for other users. Evaporation consumes 2 to 3 feet of water annually in the reservoirs. The demand for water used in the production of electricity by hydroelectric generation is measured by the additional cost of producing the same amount of energy from alternative technologies.

Hydropower has been the least costly method of producing electricity historically. Most low cost reservoirs for hydropower have already been constructed, and it is only the marginal projects that are still unbuilt.

INSTREAM USES

Instream uses for water other than hydroelectric power generation include waste disposal, recreation, preservation of fisheries and the riparian habitat and water quality maintenance. Demand for these is derived mainly from levels of environmental concerns and recreation demands.

Instream uses such as preservation of fisheries and the riparian habitat have an intrinsic value that is virtually impossible to measure. There are extreme difficulties involved with placing a value on the damages to the environment resulting from increased diversion and consumption of current streamflows.

Water quality is commonly measured in terms of total dissolved solids (TDS). The levels of TDS in a streamflow is an indication of salinity. At higher levels of salinity in irrigation water, intake of water by plants is reduced, stunting growth and/or reducing yields according to a crop's salt tolerance. Because yields are affected by changes in water salinity, net salinity damages to irrigation agriculture can be estimated. This is one measure of the value of water quality maintenance as an instream use for water.

Maintenance of instream flows and instream water quality levels provides benefits for municipalities due to the reduced treatment costs necessary to produce drinking water.

The total demand for water quality maintenance arises from the summed values, or benefits, that current and potential consumptive users receive as a result of the prevention of deteriorating water quality. This demand then combines with recreational and other demands for water quality maintenance. Maintenance of instream flow levels provides water quality benefits because water quality levels generally are directly related to flow levels. Planning decisions must recognize that although the value of instream flows is difficult to measure this does not diminish its magnitude.

DEMAND SUMMARY

Table 1 summarizes current water use and depletion in the Missouri, Yellowstone, and Columbia River Basins in Montana, and compares it with the average (mean) annual discharge from each of these three basins. This gives a gross indication of demand (and supply) in the state, though completely inadequate for identifying present and potential problem areas, as will be developed and explained later in this report.

TABLE 1. ANNUAL WATER USE[1] AND AVERAGE DISCHARGE[2] BY MAJOR RIVER BASIN

(1,000 acre-feet per year)

	Irrigation		Uses Other than Irrigation[3]		Basin Totals		Average Discharge
Basin	Withdrawal	Depletion	Withdrawal[4]	Depletion[5]	Withdrawal	Depletion	
Missouri	6,710	3,160	104	48	6,814	3,208	7,774
Yellowstone	3,490	1,650	284	37	3,774	1,687	9,543
Columbia[6]	2,210	1,040	172	46	2,382	1,086	26,610
State Totals	12,410	5,850	560	131	12,970	5,981	43,927

[1]Source: DNRC; April 1975, Water Use In Montana, pp. 7-11. These estimates are based upon 1970 water use data.

[2]Source: USGS; 1977, Water Resources Data for Montana: Water Year 1976.

[3]Uses other than irrigation include thermal-electric energy production, self-supplied industry, municipal and industrial, livestock, and rural domestic water use.

[4]Withdrawals are from both surface and ground water sources.

[5]Non-irrigation depletions are estimated by applying statewide average depletion rates for each non-irrigation use to the level of withdrawal for that use in each basin.

[6]Columbia River Basin figures combine estimates for the Kootenai River and the Clark Fork of the Columbia River in Montana.

III. LEGAL CONSTRAINTS TO WATER USE

Generally, the major legal constraints to water use in Montana include state water laws, the Constitution, laws, and treaties of the United States, and the Yellowstone Compact. This discussion briefly summarizes the laws in each of these areas and their relative importance to water development in Montana.

STATE WATER LAWS

Montana is wholly an appropriation doctrine state, and its past and current water laws are based on this doctrine. Under the appropriation doctrine the "beneficial use" of water is the basis, the measure, and the limit of a water right. The Water Use Act of 1973 defines beneficial uses including but not limited to: agricultural (including stockwater), domestic, fish and wildlife, industrial, irrigation, mining, municipal, power, and recreational uses. A water right carries with it a priority date, which is usually the date that the first act is done to initiate the right. An appropriation having a prior right in time has preeminence over all other water rights which have a later priority date. This is the "first in time, first in right" concept.

Appropriations of water under the doctrine are normally for a definite rate of direct flow diversion or storage. The key factor is that amount of water actually needed for the specified beneficial use.

Water rights, once acquired and perfected, are property rights, and they become appurtenant to the lands upon which the water is used. Like other property rights, they then may be sold or transferred, retaining their original date of priority.

In 1973 Montana enacted the Montana Water Use Act (Section 89-865 et seq., R.C.M. 1947) which, for the first time in Montana, imposed a mandatory administrative procedure over the method of acquiring and utilizing water rights. Prior to the Water Use Act, a water user in Montana could acquire a water right simply by appropriating the water and putting it to a beneficial use. No statutory procedure was necessary and consequently there are literally tens of thousands of valid water rights (termed "use rights") in Montana which are not recorded.

With the passage of the Water Use Act, a permit system of water rights administration was instituted. After July 1, 1973, no one could acquire a new water right to surface water without first applying for and receiving a permit from the State Department of Natural Resources and Conservation. The Department must grant a permit if the proposed appropriation will not "adversely affect" the rights of prior water right holders, if there are unappropriated waters available in the source of supply, if the proposed means of diversion or construction are adequate, if the proposed use is a beneficial use, and if the proposed use will not interfere unreasonably with other planned uses or developments for which a permit has been issued or for which water has been reserved.

In addition to the institution of the permit system, the new Act also prescribes procedures for transferring or changing water rights, for adjudicating through the state district courts all "existing rights", and for establishing reservations of water for future use or to preserve minimum instream flows.

In 1974 Montana enacted the Yellowstone Moratorium (Sections 89-8-104 through 89-8-111, R.C.M.) which is still in effect. The Moratorium suspends actions on all applications for permits to appropriate water for more than 20 cubic feet per second, the common measurement for flow, or 14,000 acre-feet in the Yellowstone Basin. An appropriator of more than fifteen cubic feet per second (cfs) may not change the purpose of use of an appropriation right from an agricultural use to an industrial use; however, the Department has administrative discretion to approve changes to agricultural, irrigation, domestic, and municipal uses under certain conditions.

In 1921 Montana also enacted a statute prohibiting the diversion of Montana's water across the state line without legislative approval. (Section 89-846, R.C.M. 1947). The Water Use Act specifically declares that the use of water for slurry to export coal from Montana is not a beneficial use, consequently the use of water for slurrying coal across state lines is prohibited. (Section 89-867 (2), R.C.M. 1947).

The Water Resources Act of 1967 was the first legislation in Montana aimed specifically at developing a comprehensive water plan for Montana. The Water Resources Division of the Department of Natural Resources and Conservation is responsible for developing the plan and for coordinating local, state, and federal water resource development plans and projects. The State Water Plan is mandated to be a coordinated multiple-use water resource plan designed to insure optimal beneficial use and conservation of Montana's water resources.

The State Water Plan is outlined in four phases: an inventory of the state's water resources, development of water requirements and projections for future water and related land resource use, plan formulation, and implemention of the plan. The first phase, the resource inventory, is the accumulation of detailed knowledge of the water and rlated land resources of the State of Montana and their present management and use. This phase has been largely completed and resulted in the publication of a number of inventory series reports containing the mass of information acquired during the study. Also involved in this phase is the computerization of much of the published (and unpublished) data, to facilitate use of the information for subsequent phases of water planning.

The second phase of the plan involves development of projections for future water and related resource use from a study of the information obtained in phase one regarding present water use. More detailed projections will also be established for use in subsequent river basin planning.

Phase three involves the development and publication of alternative plans, programs, and projects to be implemented by the year 2020. Development selected will be determined by the findings of the first two phases of the plan, as well as from the findings of other state, local, or federal planning efforts.

The fourth phase of the State Water Plan is the implementation of recommended plans, programs and projects. Some of this implementation will take place concurrently with present planning efforts; much will be the result of future detailed surveys of problem areas. The Flathead River Basin Level B Study was completed in 1976 and adopted, and implementation of the recommended programs and projects has been and will continue to be pursued by the DNRC.

FEDERAL LAWS

The power of the United States to regulate and control water resources stems from several sources, including the commerce clause of the Constitution. Congress may enact laws regulating commerce on navigable streams. The definition of a navigable stream has been the subject of much litigation, but it is generally accepted that "navigable" has a broad meaning; the powers of Congress even extend to tributaries of navigable streams. Under this power, Congress may authorize projects which in effect destroy navigability, such as Fort Peck Dam, and appropriate the waters for other purposes such as power generation. In a decision on July 3, 1978 (California vs. United States, No. 77-285, July 3, 1978), the Supreme Court rules that federal agencies must comply with state laws when appropriating, condemning, or purchasing water rights for federal projects, and that once the waters were released, their distribution to individual landowners would again be controlled by state laws.

Congress has, under various laws and pursuant to other constitutional authority, also authorized the Department of Interior through the Bureau of Reclamation to construct reclamation and irrigation facilities; the Yellowtail Dam on the Bighorn River is an example in eastern Montana. The Bureau of Reclamation must comply with state water laws in the construction of these projects, including obtaining a state permit.

The federal government also possesses what are termed "reserved rights" to water, (not to be confused with reservations of water under the new Water Use Act), which are not subject to state law. Under the famous Winters decision and subsequent decisions, the courts have held that when the United States withdraws (reserves) lands from the public domain, a water right is also reserved to a sufficient quantity of water arising on, flowing through, adjacent to, or under the reservation necessary for the purposes of the reserved land. The reserved water right has a priority date that is the date of the creation of the reservation, and it does not depend upon immediate beneficial use as do other appropriation rights. Consequently, there are now reserved water rights on all federal lands withdrawn from the public domain, including Indian reservations and most National Forest lands. The extent of such rights is largely unknown at present, though a recent Supreme Court decision (United States vs. New Mexico, No. 77-510, July 3, 1978) ruled that a reservation of water for federally reserved lands is in the amount necessary for primary purpose of the reservation only. Where water is only valuable for a secondary use of the reservation, the United States must acquire water in the same manner as any other public or private appropriator in the state.

YELLOWSTONE RIVER COMPACT

The Yellowstone River Compact, executed by Montana, Wyoming, and North Dakota, and ratified by the United States Congress in 1950, was designed to allocate water of the Clarks Fork of the Yellowstone, Bighorn, Tongue, and Powder rivers. The compact recognizes water rights prior to 1950, those rights designated to provide supplemental water supplies to land irrigated prior to 1950, and water rights for irrigation projects started before 1950. The compact divides the remaining water according to percentages of the flow at the mouths of the streams as shown in Table 2.

TABLE 2. DIVISION OF WATERS UNDER THE YELLOWSTONE RIVER COMPACT

Tributary	Wyoming	Montana
Clarks Fork Yellowstone	60%	40%
Bighorn	80%	20%
Tongue	40%	60%
Powder	42%	58%

Article X of the compact prohibits diversion of water out of the Yellowstone Basin without the unanimous consent of the signatory states. This article has recently become controversial because Wyoming would like to divert water out of the basin for use by the energy industry. Montana's position at this time is to withhold approval of such diversions until the two states can agree on quantification of the percentages of tributary flows. Wyoming has published its estimates of these quantities, as presented in Table 3. Montana does not necessarily agree and intends to independently calculate its compact share.

TABLE 3. WYOMING'S YELLOWSTONE COMPACT ESTIMATES (ACRE-FEET)

	Wyoming	Montana
Clarks Fork Yellowstone	429,000	285,000
Bighorn	1,800,000	400,000
Tongue	96,400	144,700
Powder	120,700	166,600
Total	2,446,100	966,300

Source: Wyoming State Engineer's Office 1973

INDIAN CLAIMS TO WATER

Indian water rights are based upon the reserved rights of federal reservations and the Winters Doctrine that arose in 1908 from a suit concerning appropriation of water on the Milk River in Montana. (Winters vs. United States 207 U.S. 564, 1908). The doctrine states that all reserved lands have an implied water right with the date of prior appropriation being the date the reservation was established. Though these rights have not been quantified, the Winters Doctrine and subsequent court decisions assert that the rights are sufficient to serve the purposes for which the reservations were established. Ensuing claims for water rights in the Northern Great Plains are declared as follows:[5]

> "The Indian tribes of the five states do hereby give notice to the world that they will maintain their ownership to the priceless natural resources which are geographically and legally related to their reservations. Indian tribes and people, both jointly and severally, have declared and the courts have sustained that the American Indian tribes of the Northern Great Plains have the prior and paramount rights to the waters of all rivers, streams, or other bodies of water including all tributaries thereto which flow through, arise upon, underlie, or border upon their reservation. These prior and paramount rights would extend to all waters that may now or in the future be artifically augmented or created by weather modification, by desalination of presently unusable water supplies, by production of water supplies as a by-product of geothermal power development, or by any other scientific or other type of means within the respective reservations in the Northern Great Plains area.
>
> In view of the tribes' prior and paramount rights to all the waters to which they are geographically related, it is self-evident that any major diversion of said waters for any purpose would constitute an encroachment upon Indian water rights. All Federal agents or agencies, including but not limited to the Bureau of Reclamation, Corps of Engineers, states, persons, parties or organizations are, therefore, put on notice that any diversion or use of such tribal waters shall be at their own risk."

The above quotation indicates the great uncertainty on how much water the Winters Doctrine allocates to the various Indian reservations in Montana. The interpretation in court decisions has been that the quantities must equal those sufficient to provide full services to all irrigable lands in the reservations. The Confederated Salish and Kootenai Tribes of the Flathead Reservation claim rights to all water arising upon, flowing through, or bordering the Flathead Indian Reservation.[6] Table 4 presents estimates of future water requirements for the remaining Indian reservations in Montana.

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[5] Native American Natural Resources Development Federation of the Northern Great Plains, "Declaration of Indian Rights to the Natural Resources in the Northern Great Plains States," June 1974, p. 1.

[6] DNRC and PNRBC, The Flathead River Basin, September 1976, p. 5.

TABLE 4. ESTIMATED WATER REQUIREMENTS 2020[a] (ACRE-FEET)

	MISSOURI BASIN				YELLOWSTONE BASIN	
Use	Blackfeet	Rocky Boy	Fort Belknap	Fort Peck	Crow	Northern Chyenne
Agriculture	644,100 322,500	128,900 64,400	173,100 86,500	413,800 206,900	1,080,000 540,000	109,200 54,600
Domestic	1,600 300	300 100	400 100	1,100 200	1,800 400	1,400 300
Industrial	800 100	100 0	200 0	600 100	7,000 1,540	300 60
Minerals	2,500 500	0 0	0 0	0 0	0 0	0 0
Energy	0 0	0 0	0 0	0 0	196,500 196,500	196,500 196,500
Forestry	0 0	0 0	0 0	0 0	0 0	0 0
Wildlife	228,600 0	2,100 0	37,500 0	1,077,200 0	823,300 0	178,800 0
Recreation	500 100	0 0	200 0	300 100	500 115	300 60
Totals	878,100 323,500	131,400 64,500	211,400 86,600	1,493,000 207,300	2,114,100 738,550	486,500 251,520

[a]Double entries indicate diversion requirements and corresponding depletions.

Source: Report on Water Energy in the Northern Great Plains with Emphasis on the Yellowstone River Basin, U.S. Department of Interior, October 1974, p. V-21.

INSTREAM WATER RIGHTS AND RESERVATIONS

Under the 1973 Water Use Act, state and federal agencies, as well as political subdivisions of the state, may apply to the Board of Natural Resources and Conservation to reserve water for existing or future beneficial uses, or to maintain a minimum flow, level, or quality of water. Before an order reserving water may be adopted, the applicant must establish to the Board's satisfaction:

1) the purpose of the reservation,
2) the need for the reservation,
3) the amount of water necessary for the purpose of the reservation, and
4) that the reservation is in the public interest.

When put to a requested use, a water reservation becomes a water right. To date the Yellowstone River Basin is the only region in Montana in which reservation proceedings have been undertaken. The Yellowstone Moratorium suspends all applications for diversions of over 20 cfs or storage of over 14,000 af in the basin until water reservations in the basin can be adjudicated and established with preference over the pending applications and priority over the subsequent applications. Major reservation requests currently under consideration in the basin include the following: 8 municipal requests totalling 391,517 acre-feet per year; an instream request by the Montana Department of Fish and Game amounting to 8,206,723 acre-feet per year at Sidney; an instream request by the Montana Department of Health and Environmental Sciences totalling 6,643,000 acre-feet per year at Sidney; 23 irrigation requests totalling 1,185,142 acre-feet per year; and 5 requests for multipurpose storage reservations totalling 1,234,000 acre-feet per year. These requests probably do not represent the actual reservation quantities that will be adopted, though the Board is expected to reach a decision late this summer.

In addition to the Water Use Act, a statute commonly known as "Murphy's Law" (Section 89-801 et seq., R.C.M. 1947) enacted in 1969 made unappropriated waters subject to appropriation by the Montana Fish and Game Commission "in such amounts only as may be necessary to maintain stream flows necessary for the preservation of fish and wildlife habitat." The appropriation has a priority right over other uses "until the district court...shall determine that such waters are needed for a use...more beneficial to the public." The instream right will not affect prior rights.

The Montana Department of Fish and Game filed applications for appropriations under the statute on eleven streams in the state and the appropriations are summarized in Table 5. The actual filings were for instantaneous flows in cubic feet per second. The flows varied for different periods in the annual cycle and for different stretches of the streams filed on. Table 5 indicates the largest annual flow in acre-feet for each "Blue Ribbon Stream."

TABLE 5. WATER FILINGS ON THE "BLUE RIBBON STREAMS" AS FILED UPON BY THE MONTANA FISH AND GAME COMMISSION

Stream	Stream Totals (af/y)	Stream	Stream Totals
Big Spring Creek	108,500	Rock Creek (Clark Fork)	503,500
Blackfoot River	877,000	Smith River	183,900
Flathead River	4,265,000	Yellowstone River	1,517,000
Gallatin River	748,000	MF Flathead	1,193,000
Madison River	996,000	SF Flathead	1,591,500
Missouri River	2,415,000		

Electric power utilities hold valid instream rights for hydroelectric generation. These rights are largely unquantified, but once adjudicated could mean extensive limitations to water availability for consumptive uses. Water use by hydroelectric plants refers to the gross or total volume of water used by all plants on a stream. Water discharged from each upstream plant is available to other plants downstream, so each plant in turn extracts a share of energy from the same unconsumed water in its gradual descent seaward. The water of the Missouri River, for example, drives turbines of 10 generating plants whose combined water use is more than the average flow of the river.

The net water requirement for hydroelectric power generation can be estimated by summing water use at only the downstream plant on each stream, as the water reaching those plants must necessarily include that discharged by the plants upstream. Table 6 shows the estimated net water requirement for hydroelectric power in Montana.

TABLE 6. NET HYDROELECTRIC POWER GENERATION REQUIREMENTS

Plant	Stream	Discharge (acre-feet)
Fort Peck	Missouri River	6,809,000
Noxon	Clark Fork River	15,330,000
Mystic Lake	West Rosebud Creek	93,460
Yellowtail	Bighorn River	2,531,000
Libby[a]	Kootenai River	8,434,000

[a]USGS, 1975.

Source: DNRC 1975, except as noted.

IV. THE SUPPLY OF WATER

Geographically, Montana is divided into three major basins: the Columbia, the Missouri, and the Yellowstone. The Columbia River Basin includes all lands in Montana west of the Continental Divide. Though it contains only 17 percent of the land mass in the state, this basin is the source of 59 percent of the state's surface water outflow. The Missouri River Basin is by far the largest of the three major basins in the state, containing approximately 56 percent of the land yet only 17 percent of the water. The area of the Yellowstone River Basin is divided nearly equally between the states of Montana and Wyoming. The Yellowstone arises in northern Wyoming and flows northeasterly to join the Missouri just inside North Dakota. The basin in Montana contains 24 percent of the state's land surface and yields 21 percent of Montana's water.

Sixty-five percent of the water available in the state originates in Montana. Total outflow from Montana averages nearly 44 million acre-feet per year. Table 7 shows the relationship between average river basin inflow and the amount originating in the state.

TABLE 7. RIVER BASIN INFLOW AND OUTFLOW (IN ACRE-FEET)

Drainage	Inflow	Originating in the State	Leaving the State	Percentage Originating in the State
Clark Fork	703,500	15,216,500	15,920,000	95
Kootenai	7,600,000	2,520,000	10,120,000	25
Missouri	893,600[a]	6,431,400	7,325,000	88
Hudson Bay	0	989,150	989,150[b]	100
Yellowstone	6,227,000	3,126,000	9,353,000	33
Little Missouri	55,930	132,500	188,430	70
TOTAL	15,480,030	28,415,550	43,895,580	65

[a]U.S. Department of the Interior 1964b and 1969.
[b]U.S. Department of the Interior 1964a.

Source: U.S. Department of the Interior 1972.

In addition to the streamflows in the three major river basins, Montana has over 1500 natural lakes and more than 60,000 reservoirs ranging in size from small stock ponds to the immense Fort Peck Reservoir. Sixty-seven of these reservoirs have capacities of 5,000 acre-feet or more. Table 8 gives the number of reservoirs, total and active storage, and surface area in the three major basins.

TABLE 8. MONTANA RESERVOIRS HAVING A TOTAL CAPACITY OF 5000 ACRE-FEET OR MORE

Basin	Number of Reservoirs	Total Storage (acre-feet)	Active Storage (acre-feet)	Surface Area (acres)
Columbia	22	11,978,365	9,811,057	223,293
Missouri	38	25,017,221	18,633,565	384,411
Yellowstone	7	1,537,429	1,517,030	24,130
TOTAL	67	38,533,015	29,961,652	631,834

The supply of water depends upon the amount of precipitation within the watershed, watershed characteristics, and the quantity of water that can be stored along the state's waterways. There is a large variation in annual flows and flow levels over the annual cycle. In this study flow variations are shown in terms of the percentage of years on average that a particular flow will be exceeded. The 50th-percentile flow is the flow that is exceeded on the average of 5 years out of 10. The 95th-percentile flow is a low flow, that is, on the average, 95 years out of 100, flows exceed this annual flow figure. The 95th-percentile flows are generally less than two-thirds of the mean annual flows.

By convention, the use of the term "average flows" refers to mean rather than median flows. Mean and median flows are usually significantly different because the statistical distribution of flows is typically a skewed distribution.

The four selected hydrographs in Figure 2 illustrate the fact that flows vary widely over the annual cycle. Note that the 50th-percentile or median monthly flows are the monthly flows that are exceeded in that month 50 percent of the years. The 90th-percentile flow is the monthly flow exceeded on the average 9 years out of 10. Figure 3 presents the median (50th-percentile) and 90th-percentile flows for the Powder River at Locate.

Figure 3 indicates that streamflow in the Powder River is lowest in July, August, and September. The demand for irrigation water, the largest consumptive use, is at its peak in the months of July, August, and September. This illustrates that seasonal fluctuations can seriously limit water availability for large-scale developments in many of Montana's drainages.

Ninetieth-percentile low flows in September in the Yellowstone River at Sidney are about 218,000 acre-feet. Although the Yellowstone River could support a significant increase in consumptive uses, the Powder River, which is one of its major tributaries, could not.

Although weather modification (cloud seeding) and certain land management practices can slightly increase the natural supply of water within a drainage, the principal method for increasing the availability of water is through reservoir storage. Storage reservoirs can greatly increase water availability in low years and low seasons by storing surplus water in periods of high flow.

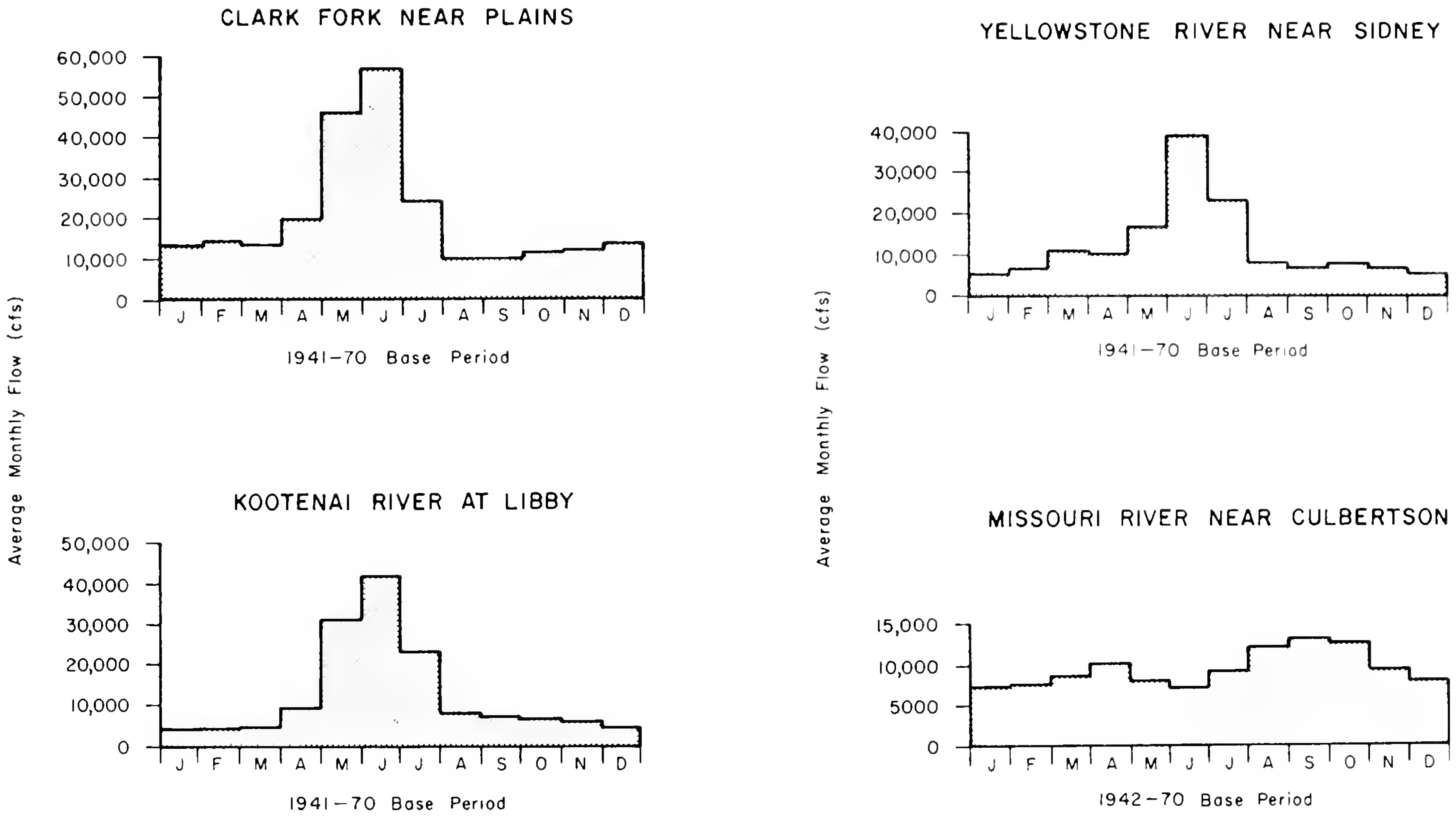

FIGURE 2. SELECTED HYDROGRAPHS

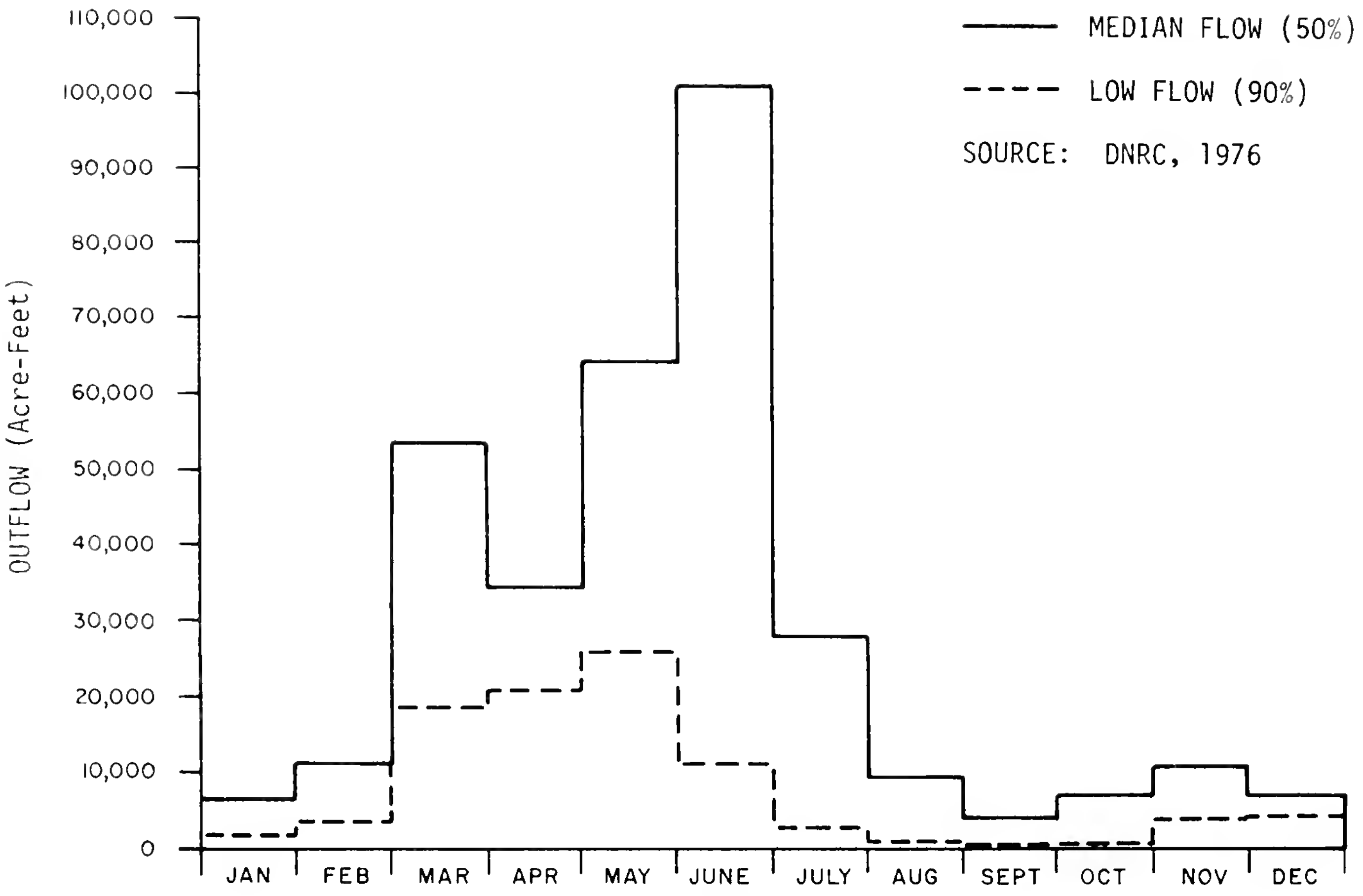

FIGURE 3. POWDER RIVER AT LOCATE

V. USE PROJECTIONS AND WATER SUPPLY

This section of the report examines studies that project future uses for Montana's water in each of the state's three major basins. Due to the large quantity of available information concerning the future of the Yellowstone River, this basin is examined first, followed by the Columbia and Missouri River basins.

Methodology and assumptions used in making the projections are discussed briefly for each study analyzed and a summary of the study projections follows. A water analysis is contained at the end of the discussion of projections for each basin. This includes critical comments on the methods, assumptions, and plausibility of the projections made by the individual studies examined. A "best guess" projection of future uses, and an analysis of available water supplies concludes the discussion on each basin.

YELLOWSTONE BASIN

Two important studies of the Yellowstone River Basin have recently been completed: the Yellowstone Impact Study (Old West Regional Commission, 1977), and the Yellowstone River Basin and Adjacent Coal Areas Level B Study (Missouri River Basin Commission, 1978). These are the studies examined in this analysis of the future of water uses in this basin.

Yellowstone Impact Study

The Yellowstone Impact Study was completed in 1977 by the Old West Regional Commission for the Montana portion of the Yellowstone River Basin. The purpose of the study was to research and document present and potential future conflicts of demand for water use in the basin. The study includes Park, Sweetgrass, Stillwater, Carbon, Yellowstone, Big Horn, Treasure, Rosebud, Custer, and Powder River counties, and those portions of Prairie, Dawson, Richland, Wibaux, Fallon, and Carter counties that lie within the Yellowstone River Basin.

The first important assumption made in the study is that if major developments occur, they will be agricultural and/or energy-industrial. Municipal water use will be determined by the two major types of development and will be of much less magnitude. Therefore, the methods and assumptions used in projecting agricultural demand are presented first followed by those used in projecting energy development, and finally, the methodology for projecting municipal water use is discussed.

Agricultural Projections. Land not currently being irrigated was classified according to slope and soil type to estimate the number of irrigable acres in the basin, without regard to water availability or crop markets. All future development was assumed to be sprinkler systems. No land more than three miles away from or more than 450 feet above the source was considered feasible to irrigate. Only the Yellowstone and the four main tributaries (Clarks Fork, Bighorn, Tongue and Powder) were considered as water sources.

Water costs were separated into water delivery costs and water application costs, with delivery costs depending on lift, distance, and the quantity of water delivered. Application costs were developed from Cooperative Extension Service information (1969) for a center-pivot sprinkler system. Each farm was assumed to be 320 acres, 302 of which were irrigated. The total diversion requirement was calculated to be 908 acre-feet per farm per year. Farm budgets were developed for each subbasin reflecting local cropping patterns, and net profits were calculated to determine the acreage that was economically feasible to irrigate. It was assumed that management skills were above average.

The model resulted in an estimated figure of 237,472 acres that are economically feasible to irrigate. One intuitively appealing aspect of this figure is that 97.6%, or 231,189 acres are no more than 1.0 miles out and virtually all acreage had lifts of 200 feet or less (222 acres had lifts in the 250 to 300 ft. range).

Three levels of irrigation development were projected from the economically feasible figure: low, intermediate, and high. The low level of development is one-third of the total feasibly irrigable acres, the intermediate level is two-thirds, and the high level of development is all economically feasible acres. Projected increases for depletions due to increases in irrigation were then estimated for each level of development for the year 2000 using a two acre-feet per acre rule of thumb.

Projections for Energy Development. The study utilized the results of the Northern Great Plains Resource Program's (NGPRP) National Report and Regional Energy Considerations Work Group (1974) and the Montana University Coal Demand Study (MUCDS) to project four alternative futures for coal production and development: base, low, intermediate, and high. The base alternative is an estimate of minimum development, a preservation alternative aimed at protection of the natural environmental quality. This alternative was considered to be probably unrealistic because it assumes virtually no further coal production beyond the 1980 level of development. Water use projections were therefore not made in the study for the base alternative.

The low level of development assumes coal development is limited to Montana demands and supplying existing and planned contracts. Projections were derived from data compiled by the NGPRP (1974), the Montana Energy Advisory Council (1974), and companies currently planning coal production for export. Synthetic fuel facilities were excluded except in the year 2000, at which time it was assumed that a single 250 million cubic feet/day synthetic natural gas plant would be necessary to replace the gas imports that Canada intends to phase out.

The intermediate level of development is simply the mean of the low and high levels of development.

The high level of development considers the highest possible development of Yellowstone River Basin coal reserves. It assumes that United States energy self-sufficiency will be a real goal, and that there will continue to be shortages of oil and natural gas.

Increases in water depletions for energy were estimated for the year 2000 for the low, intermediate, and high levels of development. This was accomplished by multiplying estimates of water use requirements for the coal processes projected to be used in Montana by the year 2000 times the projected levels of increase in coal conversion.

Municipal Water Use Projections. The method used to project energy development population increases was the Montana Futures Process (MFP) which uses a simulation model employing economic and demographic submodels. The economic submodel generates simulated employment levels by industrial sectors in a labor market area. The demographic submodel predicts simulated population levels from the simulated employment levels associated with each level of energy development projected.

Municipal population changes were estimated through considerations of past trade patterns and likely spatial development in each labor market area. Per capita use rates were combined with the projected population levels to estimate future municipal water depletions for the three energy development scenarios.

Summary of Projections. Table 9 presents a summary of the projections for increases in water depletions by the year 2000 made in the Yellowstone River Impact Study. There are several important points to note in interpreting the data. The study made no attempt to place more probability on one alternative future than another. The projections for energy development are simply a range between the two extremes of estimated maximum energy development possible and maximum preservation of environmental quality. Likewise, the projections for irrigation development are only the probable range of development levels. Note that municipal water use was tied to energy development, but that energy and irrigation development are independent. This means that a low level of energy development corresponds to a low level of municipal growth, but that no level of energy development is connected to any level of irrigation development.

Yellowstone River Basin and Adjacent Coal Area Level B Study

The report: Yellowstone River Basin and Adjacent Coal Area Level B Study was completed by the Missouri River Basin Commission management group in May, 1978. The Level B Study is a reconnaissance-level study of water and related land resources for the Yellowstone Basin and adjacent coal area in southeastern Montana, northern Wyoming, and southwestern North Dakota. The Montana portion of the study area includes all of the counties listed in The Future of the Yellowstone River.....? in their entirety plus Garfield, McCone, Rosebud and Musselshell counties.

This study derived projections for agricultural production, municipal, rural domestic and livestock water use by analyzing historical trends of water use and related land activities and projecting them to the future. This assumes continuation of ongoing federal and state programs but assumes no assitional involvement or interference.

Agricultural Production. To establish a base from which to make projections of livestock and crop production demands and capabilities, reliance was placed on a study of Agricultural Census reports for every five years, 1949-69, and Statistical Reporting Service data for 1970 through 1974. Derived

TABLE 9. THE INCREASE IN WATER DEPLETION FOR CONSUMPTIVE USE BY 2000, BY SUBBASIN

Subbasin	Increase in Depletion (af/y)			
	Irrigation	Energy	Municipal	Total
	LOW LEVEL OF DEVELOPMENT			
Upper Yellowstone	25,380	0	0	25,380
Clarks Fork	1,440	0	0	1,440
Billings Area	12,940	0	3,480	16,420
Bighorn	8,700	860	negligible	9,560
Mid-Yellowstone	16,820	35,180	1,680	53,680
Tongue	14,640	11,450	negligible	26,090
Kinsey Area	3,160	0	0	3,160
Powder	50,140	860	360	51,360
Lower Yellowstone	25,120	0	360	25,480
TOTAL	158,340	48,350	5,880	212,570
	INTERMEDIATE LEVEL OF DEVELOPMENT			
Upper Yellowstone	50,780	0	0	50,780
Clarks Fork	2,880	0	0	2,880
Billings Area	25,880	0	3,540	29,420
Bighorn	17,380	5,890	300	23,570
Mid-Yellowstone	33,640	75,490	1,860	110,990
Tongue	29,260	46,900	300	76,460
Kinsey Area	6,320	0	0	6,320
Powder	100,280	18,880	600	119,760
Lower Yellowstone	50,200	0	360	50,560
TOTAL	316,620	147,160	6,960	470,740
	HIGH LEVEL OF DEVELOPMENT			
Upper Yellowstone	76,160	0	0	76,160
Clarks Fork	4,320	0	0	4,320
Billings Area	38,820	0	3,900	42,720
Bighorn	26,080	28,150	480	54,710
Mid-Yellowstone	50,460	139,410	3,840	193,710
Tongue	43,900	118,030	780	162,710
Kinsey Area	9,480	0	0	9,480
Powder	150,400	22,600	1,140	179,690
Lower Yellowstone	75,340	13,000	480	88,820
TOTAL	474,960	321,190	10,620	812,320

"base" figures for crop acreages and production were taken as the average of 1972-74; livestock production and numbers were for 1974.

Projections of crop yields and production were based on nationally consistent OBERS[7] Series E and E'(1972) estimates. Acreages were projected on a judgement basis. Livestock production demands were projected by OBERS for six commodities--beef and veal, pork, lamb and mutton, chicken, eggs and milk. OBERS disaggregated the estimates for 1985 and 2000 to the state level and the state estimates were further disaggregated on a crop-by-crop basis using state/county data.

Municipal, Rural Domestic, and Livestock Water. For purposes of this study, estimates of 100 gpcd in rural areas to 200 gpcd in some cities were used to determine municipal water requirements, which average to about 150-185 gpcd. Consumptive use values were estimated at 35-60 percent of average per capita uses. Livestock water needs were estimated by multiplying the estimated livestock numbers, based on Series E and E' production projections, by the established consumption rates for each type of animal. Estimates were also developed for livestock impoundment evaporation which, for the study area, is greater in magnitude than the direct animal consumption.

OBERS Projections. The projections represent estimates of economic activity and land use expected to develop during the projection period if all assumed conditions materialize.

Estimated future water use depends not only on the projected economic activity, but in addition, on projected changes in the technology of water use and on the cost of water relative to its substitutes.

Six general assumptions underlying OBERS projections are:
1) fertility rate which represents replacement level fertility;
2) reasonably full employment (4 percent unemployment) nationally;
3) projections free of immediate and direct effect of wars;
4) growth in private output per manhour of 2.9 percent annually;
5) no industrial developments requiring new classifications; and
6) growth can be achieved without ecological disaster or serious environmental deterioration.

An important implication of OBERS is revealed in the following quote: "The projections are in no sense a goal, an assigned share, or a constraint on a region's economic activity. They should not constrain the planner in considering alternative levels of growth which might be achieved through more or less resource development." (OBERS series E, p. 7).

Baseline projections constitute estimates of future economic activity if there are no policy or program changes of an unforeseen nature or magnitude. OBERS projections were made in two major steps. First, the national economic

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[7] An acronym that stands for Office of Business Economics (OBE), now known as Bureau of Economic Analysis, U.S. Department of Commerce, and Economic Research Service (ERS). U.S. Department of Agriculture.

projections were made, then the projected national totals were distributed regionally using the record of each region's historical contribution.

The agricultural projection system is based largely on the extension of historical trends and the use of a land availability check to indicate the adequacy of the resources within the regions to produce the projected outputs.

The general technique for estimating future crop yields is a curvilinear Spillman regression model which implies that yields increase at a decreasing rate over time.

Non-Energy. Non-energy industrial water is comprised of water needed for manufacturing and for the mining and processing of non-energy minerals. In the case of non-energy minerals--both metallic and nonmetallic--estimates were developed initially for the state and later allocated to individual planning areas on a judgement basis.

Energy Industry. Emphasis was placed on the area's coal reserves, with potential for largescale mining and some degree of coal conversion. The assumption was made that the opportunity for added hydroelectric capacity is relatively limited.

A model was developed to provide a basis for forecasting the possible level, type and location of future energy development and associated resource requirements under alternative energy policies and programs. The basic study was conducted by Harza Engineering Company: "Analysis of Energy Projections and Implications for Resource Requirements," December 1976. The Harza model is basically a linear programming model designed to illustrate the implications of distinct scenarios of energy policy and program assumptions. Three scenarios were projected for the years 1985 and 2000.

1) A low rate of regional development, including coal production to meet only local needs and to cover exports already contracted or highly probable;

2) a most probable rate of development consistent with national energy consumption and production forecasts; and

3) a high rate of development based on the maximum contribution that the study area energy resources could reasonably be expected to make in alleviating shortages in domestic nuclear generation and eliminating national reliance on imported oil and gas.

The location, amount, and type of energy development within the study area was projected. For the initial runs of the model, an assumption was made that presently existing taxation and environmental policies would remain relatively unchanged into the future. The objective in the model was to meet demands of each scenario at the least cost for mining, coal transportation, conversion to electricity, and electrical transmission. The assumption that institutional/social/environmental obstacles to long distance slurry lines would be removed in the near future was made for the "high" scenario. It was also assumed that beyond 1990 rapid expansion of gasification will occur, and by 2000 resource availability, environmental concerns and social preferences will act as the primary constraints.

The "most probable" scenario contains the same assumptions as the "high" scenario except that long distance slurrying is precluded.

The "low" scenario includes (1) production sufficient only to meet local needs and exports already quaranteed or highly probable; and (2) no gasification to occur by the year 2000.

The baseline projections are described as the "future without" (F/WO) a plan. They assume no new policies or projects and continuation of all ongoing policies and projects. In addition to these projections the study developed a "recommended plan" (RP) for several policy changes and project developments to meet the "needs" projected in the F/WO. Implicit in the study's results is the assumption that the RP will be completely implemented with impacts similar to those estimated by the study.

Table 10 presents a summary of the projections made for the Montana segment of the Yellowstone River Basin and Adjacent Coal Area Level B Study. Because of the adjacent coal area was included in the study, the estimates do not represent the Yellowstone River Basin only. Also, county boundaries were used to approximate the basin borders. This resulted in parts of some counties not in the basin being included.

1978 Statewide Comprehensive Outdoor Recreation Plan (SCORP)

The Montana Fish and Game Commission adopted the 1978 SCORP to develop a goal-objective management system for the state's Fish and Wildlife programs. The plan describes projected wildlife, fish, and recreational resource status through 1990. The fish program establishes the goal of perpetuating all aquatic species and their ecosystems and to meet the public demand for fish in state waters. The plan divides Montana into seven fishing regions as follows: Regions 1 and 2 approximate the Columbia River Basin, Regions 3, 4, and 6 approximately equal the Missouri River Basin, except in Golden Valley, Wheatland, Garfield, and Musselshell counties, and Regions 5 and 7 approximate the Yellowstone River Basin plus the above counties excluded from the Missouri River Basin. The fisheries plan identified certain current timber harvesting practices, agriculture, energy development, mining, oil exploration, and subdivision development practices as being potentially adverse to stream habitats.

The SCORP study made supply and demand evaluations and projections for fishing that dealt largely with recreational and commercial fisheries. Although interest in nonconsumptive uses of aquatic resources (waterskiing, canoeing, other recreation, etc.) appears to be increasing, no data are readily available. The results of the study are presented here to illustrate not only that fishing demands have been increasing and are projected to continue to do so, but also that all forms of instream demands for water use, recreational and otherwise, are increasing over time.

Supply data for the recreational fishery was obtained through personal interviews with regional fisheries personnel. Stream supply data represents a minimal estimate due to the fact that lengths of the streams were estimated from USGS maps which have a negative error in small streams due to scaling.

TABLE 10. YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREA LEVEL B STUDY

ADDITIONAL WATER CONSUMPTION BY SECTOR, 1975-2000, F/WO, RP, RP PLUS F/WO[a] (ACRE-FEET/YEAR)

	Irri-gation	Energy	Domestic/ Municipal	Indus-trial	Non-Energy Minerals	Livestock[b]	Totals
Upper Yellowstone							
Future Without Plan	66,563	0	2,302	1,400	702	2,900	73,867
Recommended Plan	39,210	0	0	0	0	0	39,210
Rec. Plan + Fut. W/O Plan	105,773	0	2,302	1,400	702	2,900	113,077
Clarks Fork-Bighorn							
Future Without Plan	20,400	0	406	0	6	2,300	23,112
R P	153,455	0	0	0	0	0	153,455
R P + F/WO	173,855	0	406	0	6	2,300	176,567
Tongue-Powder							
Future Without Plan	9,300	47,448	1,424	0	7	4,800	62,979
R P	30,039	(13,200)	(1,000)[c]	0	0	1,431	17,270
R P + F/WO	39,339	34,248	424[c]	0	7	6,231	70,949
Lower Yellowstone							
Future Without Plan	133,125	48,757	1,120	400	15	10,000	193,417
R P	83,176	0	0	0	0	0	83,176
R P + F/WO	216,301	48,757	1,120	400	15	10,000	276,593
Basin Totals							
Future Without Plan	229,388	96,205	5,252	1,800	730	20,000	353,375
R P	305,880	(13,200)	(1,000)	0	0	1,431	293,111
R P + F/WO	535,268	83,005	4,252	1,800	730	21,431	646,486

[a] Given implementation of all projects, disregarding minimum instream flows.
Parentheses indicate negative numbers.
[b] Livestock use includes eveporation.
[c] Projected municipal consumption in the Tongue-Powder Subbasin is contradictory to projected population.

Mark-and-recapture techniques were used to estimate standing crops in selected portions of Montana's streams. It was assumed that 40 percent of the standing crop of trout at least eight inches in length could be harvested on a sustained yield basis. The supply of harvestable fish in each stream was determined by multiplying stream length by the harvestable fish per mile. This number was converted to an equivalent number of fisherman-days of recreation fishing based on catch rates from recent creel studies.

Demand data was determined from residential population data from the Department of Community Affairs, annual license sales from 1970-75, and an estimate of annual fishing pressure calculated from the results of a mail survey. Projected levels of demand were based on 3 assumptions: 1) trends in fishing license sales for the period 1970-75 would continue; 2) the relationship between license sales and annual fishing pressure during 1975-76 would continue; and 3) future trends in angler use by residents and non-residents would be similar.

Commercial fishing harvests were anticipated to continue at about 700,000 pounds per year through the planning period.

Table 11 presents a summary of the fishery supply and demand projections from SCORP for streams (excluding lakes) in Montana. Because SCORP data is not calculated by river basin, information for the entire state is presented here and will not be reported in the section dealing with the Columbia and Missouri River basins.

TABLE 11. PROJECTED DEMAND AND SUPPLY OF MONTANA'S STREAM FISHERIES TO 1990

(Fishing Days)

		TROUT		OTHER SALMONIDS		NON-SALMONIDS	
		1976-77	1990	1976-77	1990	1976-77	1990
Columbia River (Regions 1 & 2)	Supply	567,400	554,700	393,000	393,000	-	-
	Demand	439,000	617,000	58,100	81,500	-	-
Missouri Basin (Regions 3, 4 , & 6)	Supply	862,000	876,000	260,000	260,000	284,000	285,000
	Demand	708,600	996,100	70,200	98.300	67,800	95,200
Yellowstone Basin (Regions 5 & 7)	Supply	219,600	203,600	102,000	102,000	223,000	225,500
	Demand	161,200	233,600	17,900	24,700	104,500	146,500

ANALYSIS

The Yellowstone River Impact Study made several limiting assumptions in projecting agricultural development. These include:

1) no regard to water availability in determining feasibly irrigable acres. Perhaps the single most important aspect of economical irrigation development is whether or not an adequate, dependable supply of water exists.

2) consideration of only the mainstem and four major tributaries as sources. This obviously eliminates feasible acres close to minor tributaries or more than three miles back from or 450 feet above the major tributaries.

3) pumping assumed to be only directly from the source. This eliminates high-line canals and storage projects offstream that could possibly reach fertile lands.

4) management skills assumed better than average. Obviously, the average farmer is not above average.

5) ten-year amortization of equipment at a 10 percent rate of interest. This is an extremely short life span for some farm equipment and a high rate of interest for farmers to pay.

The Yellowstone River Basin and Adjacent Coal Area Level B Study projects only harvested crop acreage in estimating irrigation demands. Projects were analyzed on an individual basis and total acres summed without much evident regard for total water availability. For example, for year 2000 in the Tongue-Powder Subbasin, private development of irrigation is projected to increase 5000 acres. Without additional storage or some other increase in the water supply, there is no additional water available for development in this subbasin. Also, the projected increase in irrigation consumption in the Clarks Fork-Bighorn Subbasin seems to be disproportionately large. The Hardin Unit in that region will service approximately 85 percent of the proposed public development, and the Bureau of Reclamation estimates net depletion for this project to be only 68,500 acre-feet per year.[8] It is very unlikely that the remaining 15,270 acres of projected development will consume 105,355 acre-feet per year.

This study, as well as several others presented later in this report, relies upon OBERS projections for the base line alternative. The OBERS system of projecting future economic activity is quite adequate for national levels, but there are inherent problems involved with the disaggregation process, especially when the projections are broken down to county levels. The problems result from the fact that average historical production contributions of small areas to the national economy are poor indicators of future marginal production. For example, OBERS series C projections for the 1980 population in Montana was exceeded by 25,000 people in 1975, according to Montana Department of Community Affairs estimates. OBERS series E and E' project even lower levels of population than the C series. Also, according to the Montana Department of Agriculture and the Statistical Reporting Service of the USDA (1976) irrigated acreage in the state in 1975 met the 1980 levels projected by both OBERS series C and E estimates.

Rapid expansion of gasification beyond 1990, as assumed in the Harza "most probable" scenario, is not likely to occur unless there are massive government subsidies for the development of this process.

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[8] Bureau of Reclamation: "Preliminary Issue Paper: Yellowstone Basin and Adjacent Coal Area Level B Study," January 7, 1977, p. 1.

"BEST GUESS" PROJECTION

The markets for energy and for agricultural products are the essential determinants of future developments in both irrigation and energy production water use. It is apparent that the future of both markets is difficult to predict. The "best guess" projections for increased water consumption in the Yellowstone Basin by the year 2000 are as follows:

Irrigation	150-250,000 acre-feet/year
Energy	100-150,000 acre-feet/year
[a]Municipal and Industrial	7-9,000 acre-feet/year
TOTAL	257,409,000 acre-feet/year

[a]Municipal and industrial use was assumed to depend largely upon energy development and resulting population increases.

Due to the reconnaissance nature of the projections and the methodological problems with the studies that made the projections, these "best guess" estimates are only plausible guesses, have an extraordinary margin for error and do not provide a reliable basis for identifying future shortages and problems.

WATER SUPPLY

Figure 4 presents the 50-th percentile (median) and 90th-percentile (low) monthly outflows of the Yellowstone River.

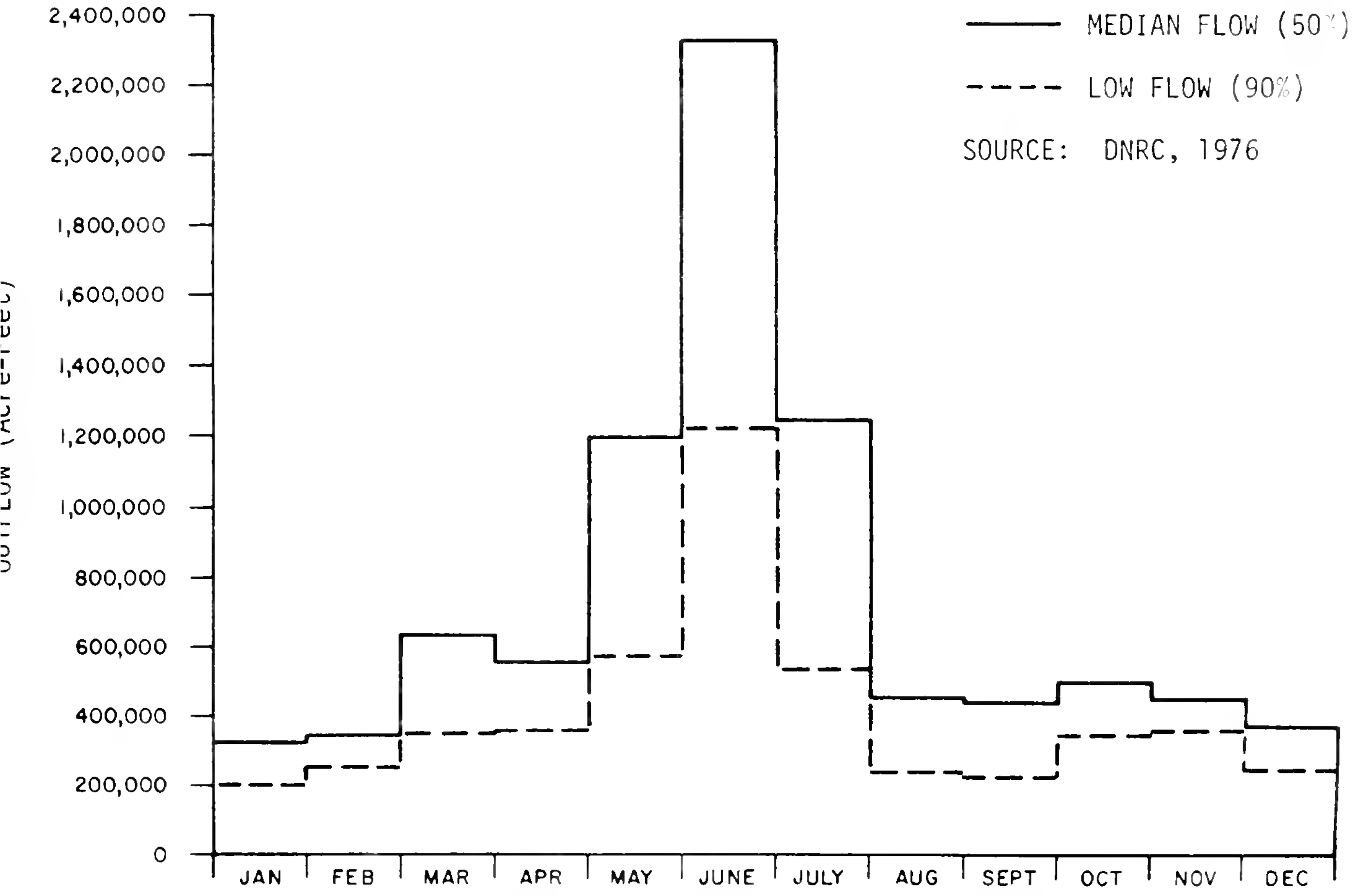

FIGURE 4. YELLOWSTONE RIVER AT SIDNEY

Table 12 lists the major tributaries to the Yellowstone River, their average annual discharge, and the percentage contribution made to the Yellowstone's average annual discharge.

TABLE 12. YELLOWSTONE RIVER BASIN AVERAGE DISCHARGE AND OUTFLOWS

Stream	Average Discharge (Acre-Feet)	% of Total Outflows
Yellowstone near Sidney	9,520,000	100.0
Stillwater near Absarokee	704,900	7.4
Boulder near Big Timber	449,200	4.7
Clarks Fork near Silesia	922,300	9.7
Bighorn at Big Horn	2,864,000	30.1
Tongue at Miles City	320,200	3.4
Powder near Locate	450,600	4.7
Yellowstone at Livingston	2,729,000	28.7

BASIN SUMMARY

The data discussed in this section on water use projections and supply analysis is not sufficient to identify potential shortages or water use conflicts. It would be a mistake to conclude that where average and 90th-percentile flows exceed projected uses, water will be available for the projected consumptive uses. Present instream rights and instream reservations, if granted, would limit depletions of historical flows. In addition, unquantified rights for future consumptive uses exist with priority dates that are senior to any rights granted in the future for the projected uses. The data are also inadequate for detailed analysis of potential shortages and problems because the projections estimated only the annual projected depletions. Severe shortages can occur, although on an annual basis unappropriated waters exceed annual projected uses because flow in critical months would be less than monthly projected uses. In other words, although in spring flows may be more than adequate, late season flows may not be adequate. This data is also inadequate because 50th- and 90th-percentile flow data fails to consider the different values placed on reliability for different uses. Agricultural operations are generally viable if they have a full supply 8 years out of 10, while municipal and industrial water uses must plan for nearly 100 percent reliability. Fiftieth and 90th-percentile flow figures do not allow a comparison of available flows and projected uses during the high-demand periods of drought years. For the reasons listed above, a comparison of projected uses and historical flows will fail to identify or may understate future conflicts.

However, the comparison also fails to account for the effects that altered reservoir operations and additional storage could have in alleviating the conflicts. Two major tributaries, the Bighorn and Tongue Rivers, have mainstem reservoirs.

A mainstem reservoir on the Powder River and several offstream reservoirs that would divert water from the Yellowstone River are under consideration. Additional storage would alter the shape of the hydrograph for the Yellowstone and its tributaries and reduce late-season shortages.

The above observations on senior instream rights, unclaimed consumptive rights, seasonal and annual fluctuations and the impacts of potential storage mean that reliable conclusions on future problems cannot be derived from the use projections and supply analysis. Only a detailed hydrologic analysis, beyond the scope of this study, based on reliable information on current unquantified rights, would permit an accurate assessment of future problems. The conclusions made in Section IV are based largely on the judgement of the DNRC Water Planning Bureau and are not primarily derived from the supply and demand analysis presented earlier.

The projections that seem likely for increased water consumption in the Yellowstone River Basin total 257,000 to 409,000 acre-feet per year by the year 2000. Water availability does not appear to be a physical constraint to this development in the mainstem of the Yellowstone. Even during low flow years there is considerable instream water available in the mainstem although significant depletions will adversely affect instream uses. However, in certain tributaries, including the Tongue and Powder rivers, there is no additional water available for full-service irrigation at present. Full-service irrigation means an adequate water supply throughout the irrigation season. Adjudication of Indian water rights in the Bighorn River could result in appropriations to the Crow and Cheyenne Indians that would seriously limit water availability to both current and potential water users. These limits are especially critical in August, a crucial month for irrigation demand and the month of lowest instream flows in most Montana rivers. The implication is that though development can occur in some areas, other areas cannot undergo significant additional development without more storage.

In the Tongue River Basin at the present time, all the firm annual yield of Tongue River Reservoir - 40,000 acre-feet per year-is committed to existing uses. TDS concentrations in the Tongue River already exceed 500 mg/l (the recommended upper limit for drinking water) two-thirds of the year, and average over 700 mg/l during December and January. Irrigation expansion would be constrained by the limited water supply, increased salinity due to additional irrigation, and the probable inability of irrigators to pay for the necessary increased storage. Irrigation expansion, if it were to occur, would require a financially subsidized water supply. Extensive development would result in diminished instream flows adversely affecting fisheries and water quality and would decrease the sediment transport capacity of the river.

The Powder River can presently sustain no significant additional development because of extreme streamflow fluctuations and the lack of water storage. Salinity is a problem which will be aggravated by any irrigation development beyond present levels. TDS concentrations currently exceed 1,200 mg/l nine months out of the year, including July, August, and September, the peak demand months for irrigation. Such high levels of dissolved solids severely limit the usefulness of Powder River water for irrigation. Substantial flow reductions could also result in significant water temperature increases. This, combined with TDS increases, would decrease the spawning and recruitment of channel catfish, sauger, shovelnose sturgeon, and paddlefish in the Powder River if extensive development and streamflow depletions occur.

COLUMBIA RIVER BASIN

The major subbasins of the Columbia River in Montana are the Clark Fork and the Kootenai river basins. Several studies have been completed on the Clark Fork River and its tributaries, including: the Clark Fork of the Columbia River Basin Cooperative Study (USDA Type IV Study, 1977), The Flathead River Basin Level B Study of Water and Related Land Resources (DNRC & PNRBC, 1976), and the Upper Flathead River Basin Study (DNRC, 1977). No studies have been completed exclusively on the Kootenai River, though the basin was included in the Columbia-North Pacific Region Comprehensive Framework Study (PNRBC, 1972).

Clark Fork Type IV Study

The Clark Fork of the Columbia River Basin Type IV Study was completed in 1977 by the U.S. Department of Agriculture in cooperation with the Montana Department of Natural Resources and Conservation. The study was conducted to help plan for the use and development of water and related land resources in the basin as part of the Montana State Water Plan. The study area includes Flathead, Lake, Sanders, Mineral, Missoula, Powell, Granite, Ravalli, Deer Lodge, and Silver Bow counties as an approximation of the basin in Montana.

The projections in the Type IV study of the Clark Fork River were based on OBERS series C (1972) projections. The main difference between OBERS series C and series E projections lies in the assumptions made concerning population growth rates. The series C projections assume a more rapid growth rate than the series E projections. The Clark Fork study area corresponds to OBERS Water Resources Sub-area (WRSA) 1702 if two counties, one in Idaho and one in Washington, are excluded. Population projections from OBERS were adjusted for the study because the Clark Fork study area has grown more rapidly than Bonner and Pend O'Reille counties.

The OBERS projections estimated decreasing acreages for irrigated cropland and increasing livestock production; this was considered inconsistent, as most crops in Montana are grown for the purpose of beef production. Therefore, a modified OBERS series C projection for agriculture was derived which assumes no increase in oats and nearly straight-line increases in hay productions (see Table 13, page 33). Though this least-cost linear programming model resulted in greater projected acreage than OBERS series C, the modified projections are still less than current normal irrigated acres.

The objective function of the linear programming model was to minimize the cost of producing the various amounts of crops and forage projected for 1990, 2000, and 2020 by varying the land use patterns. Because OBERS do not project range, dry pasture, or grazed woodlands, the study assumed they would remain constant. Irrigated crop budget costs were estimated, using data for sprinkler irrigation methods. Water and management costs were not included in the model.

There were no energy industry projections.

TABLE 13. ESTIMATED LEAST-COST LAND USE REQUIREMENTS FOR THE MODIFIED OBERS PROJECTION OF CROP PRODUCTION FOR 1990, 2000, AND 2020 WITH COMPARISON WITH CURRENT NORMAL BY SUBAREA

Clark Fork of the Columbia Basin

Item	Current Normal Prod.	Least-cost for Current Normal Prod.	1900	2000	2020
	-----	-----	acres.	-----	-----
Upper Clark Fork					
Irrigated cropland	121,682	51,428	100,959	98,178	111,955
Irrigated perm. pasture	28,640	28,640	28,640	28,640	28,640
Nonirrigated cropland	23,632	88,398	44,349	47,131	79,337
Subtotal	173,954	168,466	173,948	173,949	219,982
Other nonirrigated[a]	1,284 686	1,284,686	1,284,686	1,284,686	1,238,649
Lower Clark Fork					
Irrigated cropland	92,833	60,813	86,857	80,127	91,923
Irrigate perm. pasture	77,938	77,937	77,937	77,937	77,937
Nonirrigated cropland	65,546	90,195	70,714	77,448	113,625
Subtotal	236,317	228,945	235,508	235,512	283,435
Other nonirrigated[a]	1,304,696	1,304,696	1,304,696	1,304,696	1,256,725
Flathead					
Irrigated cropland	76,824	43,705	72,860	68,296	74,203
Irrigated perm. pasture	54,713	54,713	54,713	54,713	54,713
Nonirrigated cropland	139,758	171,078	143,130	147,693	163,468
Subtotal	271,295	269,496	270,703	270,702	292,384
Other nonirrigated[a]	605,588	605,588	605,588	605,588	583,913
Clark Fork Study Area					
Irrigated cropland	291,339	155,946	260,676	246,601	278,081
Irrigated perm. pasture	161,291	161,290	161,290	161,290	161,290
Nonirrigated cropland	228,936	349,671	258,193	272,272	356,480
Subtotal	681,566	666,907	680,159	680,163	795,851
Other nonirrigated	3,194,970	3,194,970	3,194,970	3,194,970	3,079,2[illegible]

Source: Clark Fork study area linear programming model (USDA, 1977).

[a]Includes private and state dry pasture, range, and forest land grazed.

Current municipal and industrial water use was estimated to be 153,000 acre-feet per year, with consumption being approximately 40 percent of usage. The study estimated this amount could increase to as much as 214,000 acre-feet per year, then concluded that conservation could be instituted to keep requirements at or below present levels.

Summary of Projections. The Type IV study recommended a "preferred plan" that would result in the following estimated changes in water use by the year 1990:

1) About 2,000 acre-feet per year of stored water will be used in late summer on acres now irrigated;

2) approximately 35,000 more acre-feet will be used on 14,000 acres of newly irrigated land;

3) savings of 126,000 acre-feet per year will result from conversion of 126,000 acres of flood irrigation to sprinkler, resulting in a net reduction of 89,000 acre-feet per year of water used in irrigation; and

4) municipal and industrial water use will increase in proportion to increases in population and manufacturing, but the increased consumption will be insignificant compared to total water available in the basin.

Flathead River Basin Level B Study

The Flathead River Basin Level B Study was completed in 1976 by the Pacific Northwest River Basins Commission for the DNRC. The study was adopted as the first part of the State Water Plan. The study area includes Flathead and Lake counties and small portions of Missoula and Sanders counties within the Flathead Basin.

The Flathead Level B Study used OBERS series C projections as baseline projections for the study. Series E projections were also considered, but were felt to be unrealistic due to their projection of a declining population for the study area, while in fact, population is expected to continue increasing through the planning period. An alternative set of projections extrapolating recent growth trends in the basin into the future was developed by the Areawide Planning Office in Kalispell. The DNRC developed alternative projections for new irrigation, reflecting the OBERS rate of growth for anticipated red meat production through increased acreage of irrigated cropland.

Municipal, industrial, and other non-irrigation water use in the basin was estimated to more than double the 1970 amount of nearly 16 million gallons per day by 2020. Projected municipal and rural requirements were based on an assumption that 50 percent of the projected basin population will be served by municipal systems in 1980, 55 percent in 2000, and 60 percent in 2020.

There were no comprehensive totals presented in the study as to the water use impacts of the "selected plan" resulting from the study. However, the plan was not assumed to affect the growth of population or industry, and an additional

14,500 acres of irrigated land was estimated to be developed as a result of the implementation of the Creston Bench Project. Until the year 2000, a diversion requirement of 4 acre-feet per acre with a depletion rate of 2 acre-feet per acre was assumed for irrigation. Beyond 2000, more efficient water use was assumed, implying a 3 acre-feet per acre diversion requirement with 2 acre-feet per acre depletion rate.

No major industrial expansion was projected for the study area.

Summary of Projections. Table 14 and 15 summarize the projections made in the Flathead Level B Study. There were no estimates of water consumption presented in the study.

TABLE 14. PROJECTED DOMESTIC, LIVESTOCK, AND INDUSTRIAL WATER USE IN THE FLATHEAD BASIN

(AF/Y)

	1970	1980	2000	2020
Municipal	7,970	9,540	14,025	20,760
Rural Domestic	3,140	3,590	5,720	7,970
Livestock	1,350	1,570	1,910	2,130
Industry	5,270	5,270[a]	5,270[a]	5,270[a]
TOTAL	17,730	19,970	26,925	36,130

[a]No projection made because growth is highly variable.

TABLE 15. PROJECTED ADDITIONAL IRRIGATED ACRES IN THE FLATHEAD BASIN

	1980	2000	2020	Selected Plan	Total to 2020
OBERS Series C	14,500	18,000	24,000	-	-
Alternative	9,800	29,400	49,000	14,500	63,500

Upper Flathead River Basin Study

The Upper Flathead River Basin Study was completed by the DNRC in 1977 as a result of a proposed coal development on Cabin Creek in Canada. The purpose of the study was to estimate possible impacts to Montana due to the development of Cabin Creek coal. The study area includes the northern portion of Flathead County and that part of British Columbia within the Flathead Basin.

A water use survey was circulated to landowners on the upper Flathead Basin in an attempt to project water demands into the future. A 32 percent response was compiled, and was assumed to represent one-third of the water use in the area. Population in Flathead County was projected by the Flathead County Areawide Planning Organization. These are the only projections presented in the study; the water use projections are summarized in Table 16. It should be noted that the reliability of data from a water use survey and projections based on that data are questionable.

TABLE 16. FUTURE WATER USE - UPPER FLATHEAD RIVER BASIN

Year	Additional Amount of Water Required (Acre-Feet)
1977	10,578
1978	11,140
1979	121
1980	6,333
1985	322
1990	28
2000	202

Columbia-North Pacific Region Framework Study

The Columbia-North Pacific Comprehensive Framework Study was completed in 1972 by the Pacific Northwest River Basins Commission for the purpose of providing a guide to the management, use, development, and conservation of the Columbia River Basin's water and related land resources. The Montana portion of the study area includes all of the state west of the continental divide.

The projections in this study were based mainly on data compiled by the Office of Business Economics and the Economics Research Service. The estimated acreages of irrigated croplands in the study area were modified so that small grains, hay, and pasture were projected to be the major irrigated crops, with little or no sugarbeets, dry beans, peas, or vegetables. Two assumptions were made in estimating the development of irrigated land: (1) only one-half of the average flow could be utilized for irrigation; and (2) all presently listed irrigated lands have a full supply of irrigation water. For the Montana portion of the study area, water delivery and depletion requirements were estimated to be 2.1 acre-feet per acre and 1.6 acre-feet per acre, respectively, until the year 2000. Beyond 2000, the requirements were estimated to be 2.6 and 1.9 acre-feet per acre, respectively. Increased depletions to stream flows due to irrigation were projected to reach 1,344,800 acre-feet per year by 2000 and 2,103,850 acre-feet per year by 2020. Industrial growth indices were estimated with no reference to corresponding increases in water use or depletions. Although such usages could be estimated through a comprehensive study of industrial activity in the Montana portion of the study area, it is beyond the scope of this report to do so.

Summary of Projections. Tables 17, 18, and 19 summarize the projections for water use in the Montana portion of the Columbia River Basin as presented in the Columbia-North Pacific Framework Study. The study did not include consumptive use projections for irrigation or industry. For this reason Tables 17 and 18 present only the parameters for growth in these areas that were projected in the study.

TABLE 17. PROJECTED MUNICIPAL, RURAL-DOMESTIC, AND LIVESTOCK WATER USE
(Acre-feet per Year)

	1970	1980	2000	2020
Clark Fork				
Municipal	34,890	38,820	45,780	53,520
Rural-Domestic	4,490	5,270	5,950	7,400
Livestock	4,490	5,160	6,840	8,980
Flathead				
Municipal	8,530	9,540	12,340	14,810
Rural-Domestic	3,140	3,810	4,940	6,170
Livestock	2,220	2,360	3,140	4,150
Kooteani				
Municipal	3,590	3,930	6,060	9,090
Rural-Domestic	1,910	2,240	2,690	2,690
Livestock	340	450	560	560
TOTAL	63,390	71,580	88,300	107,370

TABLE 18. PROJECTED INDUSTRIAL GROWTH INDICES (BASE YEAR 1963 = 1.00)

	1980	2000	2020
Primary Metals	1.29	1.44	1.74
Pump and Paper	1.95	3.29	3.59
Lumber and Wood Products	.99	.91	.87
Food Products	1.43	2.03	2.84

TABLE 19. PROJECTED IRRIGATION ACREAGE BY SUBBASIN (1,000 ACRES)

	1966	1970	1980	2000	2020
Clark Fork	294.5	315.1	373.8	503.1	665
Flathead	141.7	151.4	186.0	319.1	425
Kootenai	10.4	11.0	13.9	18.3	140
TOTAL	446.6	477.5	573.7	840.5	1,240

Analysis

The Clark Fork Type IV Study utilized OBERS projections to estimate "gaps" between future demands and supplies, interpreting the difference as "needs." In order to meet these "needs," which supposedly justify the existence of such studies, projects and plans are proposed and implemented for the "purpose" of efficient use of resources.

Any study which repeatedly uses such words as "needs," "necessities," or "requirements" is extremely difficult to analyze in an economic light. This is because the concept of need is a direct denial of the laws of supply and demand. If there is such a gap between quantities supplied and demanded at a price that results in some individuals not being able to purchase all that is desired, prices will rise. Higher prices mean greater supplies and lower demands.

The only situation, therefore, in which a shortage, or "need," can continue to exist for long-run periods of time is one in which supply and demand are perfectly inelastic, i.e. absolutely irresponsive to price or one in which market forces cannot operate.

The results of the linear programming model seem to be unrealistic. Unless farmers in the Clark Fork region are quite irrational in their management behavior, there is little reason to believe that current land use patterns would change so that 70,000 more acres of cropland are irrigated than would be if land were used in a "least-cost" manner. This tends to throw a shadow of suspicion over all the results of the linear programming model.

The other study summarized in this section that is relevant to the purposes of this report is the Columbia-North Pacific Framework Study. In this study, the assumption that all presently listed irrigated lands have a full supply of irrigation water is incorrect. The projected increased irrigation in the Flathead River Basin would seriously deplete instream flows in the late summer months. It is doubtful that 7,300 acres of land will be developed in the mountainous Kootenai Valley, though this overestimation is probably due to the inclusion of Boundary County, Idaho, in the Kootenai Subbasin.

"Best Guess" Estimate

The limiting factors for development of water use demands in the Montana portion of the Columbia River Basin are not related to water availability but to the availability of land and raw materials associated with water use. The assertion made in the Flathead Level B Study that municipal and industrial water use increases will be insignificant when compared to total water available is probably correct. The conclusions of this report in regard to future water demands in the Columbia Basin in Montana are that municipal and industrial water use will increase 25,000 acre-feet per year by 2000, irrigation depletions will increase from 250,000 to 350,000 acre-feet per year by 2000, and there will be no thermal-electric energy development in the area. There is however, a projected development of hydroelectric power at Libby Dam. A reregulating dam is currently being studied which would increase the ability to reach peak loads rapidly at the present generating plant. This will not affect consumptive uses, though approximately ten miles of fisheries and riparian habitat will be displaced.

Due to the reconnaissance nature of the projections and the methodological problems with the studies that made the projections, these "best guess" estimates are only plausible guesses, have an extraordinary margin for error and do not provide a reliable basis for identifying future shortages and problems.

Water Supply

Figures 5 and 6 present the 50th- and 90th-percentile monthly discharges of the Clark Fork and Kootenai rivers as they exit Montana.

The hydrograph for the Kootenai River is not representative of current outflows due to regulation of flows by Libby Dam which began operating in 1975. Flows are now higher in the winter months than in the summer, and monthly differences between flows are much less than indicated in the hydrograph.

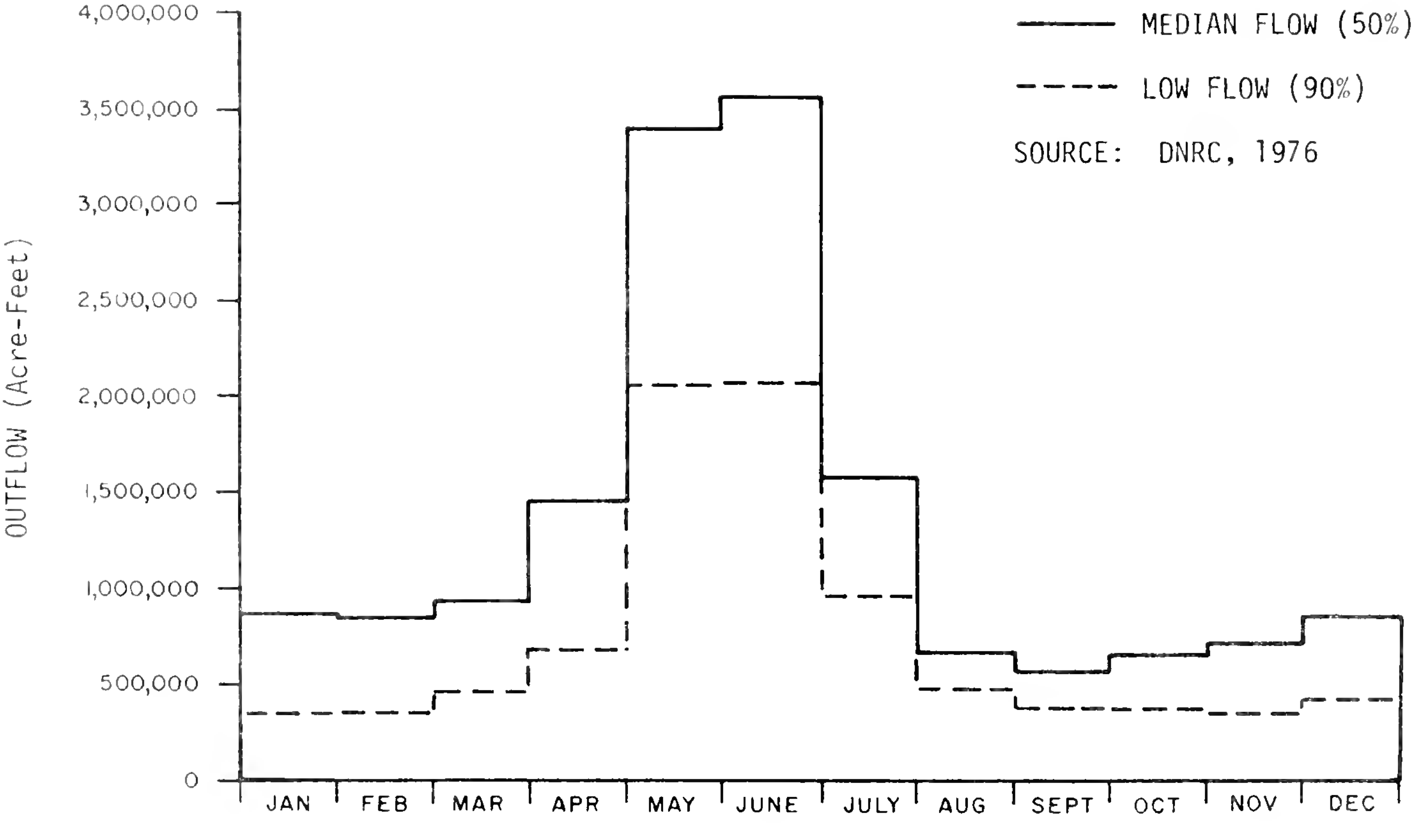

FIGURE 5. CLARK FORK AT WHITEHORSE RAPIDS

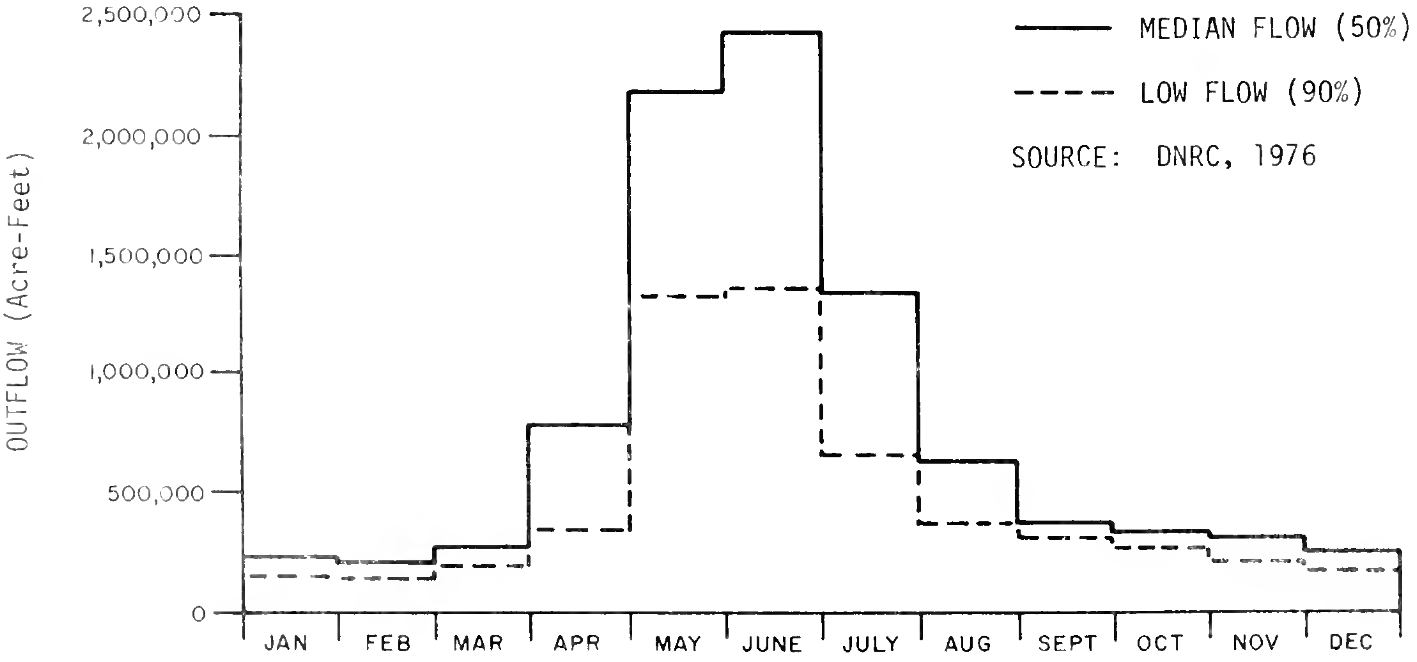

FIGURE 6. KOOTENAI RIVER AT LEONIA

Table 20 presents a list of the major tributaries of the Kootenai and Clark Fork rivers, their average annual discharges, and percentage of contributions to average outflows from the state.

TABLE 20. DISCHARGES AND PERCENTAGE OF TOTAL OUTFLOW BY TRIBUTARY IN THE COLUMBIA RIVER BASIN

Stream	Average Discharge (Acre-Feet)	% of Total Outflows
Kootenai at Leonia, Idaho	10,190,000	100.0
Fisher near Libby	411,500	4.0
Tobacco near Eureka	205,800	2.0
Yaak near Troy	685,400	6.7
Clark Fork near Noxon	15,990,000	100.0
Flathead near Polson	8,556,000	53.5
Thompson near Thompson Falls	361,500	2.3
Blackfoot near Bonner	1,202,000	7.5
Bitterroot near Florence	1,629,000	10.2

Basin Summary

Consumptive water use is projected to increase a total of 275,000 to 375,000 acre-feet per year by the year 2000 in the Columbia River Basin in Montana. In general the basin has plenty of water and water availability is not a physical constraint to development of all types. Adjudication of Indian water rights in the Flathead Indian Reservation may seriously limit water availability in the Flathead River and its tributaries. The Indians of the Flathead Reservation are currently claiming rights to all waters rising upon, passing through or adjacent to the reservation.

The Army Corps of Engineers has begun work on the installation of four additional generators in the powerhouse at Libby Dam and plans to construct a reregulating dam ten miles downstream to reduce streamflow fluctuations in the Kootenai River that would otherwise result from the proposed conversion to peaking operation at Libby Dam. In recent months the proposed addition of generators has stirred considerable controversy. Various organizations and individuals have begun to question the need for the additional peaking power, the wisdom of inundating 10 more miles of the Kootenai River, the use of a reregulating facility to smooth river flows only to existing maximum limits, and the impact of the project on the bald eagle, which inhabit the area. Although it seems likely that the project will be completed, it represents present and potential future conflicts between Montana's environmental concerns and regional power production.

THE MISSOURI RIVER BASIN

The Missouri River begins where the Madison, Jefferson, and Gallatin rivers converge near Three Forks, Montana. Other major tributaries within the state include the Sun, Marias, Milk, and Musselshell rivers. Several studies have been completed on the Montana portion of the Missouri River Basin, including: The Missouri River Basin Comprehensive Framework Study (Missouri Basin Interagency Committee, 1971) and the Missouri River Basin Water Resources Plan (Missouri River Basin Commission, 1977). Two studies have also been recently completed on tributaries to the Missouri River. They are: Supplemental Water for the Milk River (DNRC, 1977), and Joint Studies for Flow Apportionment Poplar River Basin in Saskatchewan and Montana (International Souris-Red River Board, Poplar River Task Force, 1976).

The Missouri River Basin Comprehensive Framework Study

The Missouri River Basin Comprehensive Framework Study was completed in 1969 by the Missouri Basin Inter-Agency Committee as a reconnaissance-type resource investigation. The Montana section of the study area includes all of the state east of the Continental Divide. The Upper Missouri Subbasin in the study excludes the Yellowstone River Basin, defining the region relevant to this report as approximated by county lines.

OBERS series B (1965) projections formed the baseline for future economic activity in this study. Water Resources Subareas 1002-1006 inclusive, constitute the county line-approximated Missouri Basin in Montana. Irrigation development was projected, taking into account forecasts of probable individual farm irrigation development in the basin, and potentially feasible multipurpose projects. Future livestock water consumption was estimated from projected livestock production.

Municipalities were inventoried individually and current per capita use was multiplied by projected population in estimating future demands. Industrial uses were divided into mineral-related and other industry. Generalized areas of demand were estimated, based on availability of raw materials and projected economic activity (OBERS).

Projections of future electric power requirements through 1990 were based on information provided by the major electric utilities operating in the basin. Energy demands were compared with population projections. For the period of 1990 to 2020, projections were completed by the Federal Power Commission based on estimates and trends to 1990. The assumption was made that certain hydroelectric plants would be constructed in the basin. The outputs of the assumed hydroelectric plants were used to determine the amounts of thermal-electric energy "required" to meet total demands for the future, and the demand for water for thermal power production.

Summary of Projections. Tables 21 and 22 summarize the water use projections for all uses other than irrigation for the Montana portion of the Missouri River Basin as made in the Missouri River Basin Comprehensive Framework Study. Irrigation was projected to increase 192.000 acres by 1980; 407,000 acres by 2000; and 550,000 acres by 2020.

TABLE 21. PROJECTED MUNICIPAL AND RURAL DOMESTIC, INDUSTRIAL, AND LIVESTOCK WATER USE (THOUSAND ACRE-FEET PER YEAR)

	1965	1980	2000	2020
Municipal and Domestic	46	52	66	94
Mineral	2	6	7	3
Other Industry	31	37	57	59
Livestock[a]	146	203	211	225
TOTAL	225	298	341	381

[a]Includes pond evaporation

TABLE 22. PROJECTED WATER DIVERSION FOR THERMAL-ELECTRIC POWER GENERATION (ACRE-FEET PER YEAR)

Type of Cooling	1980	2000	2020
Flow-through	156,500	429,400	413,600
Cooling Pond	1,050	3,750	8,870
Cooling Tower	1,910	11,410	32,670
TOTAL	159,460	444,560	455,150

Missouri River Basin Water Resources Plan

The Missouri River Basin Commission prepared the Water Resources Plan in 1977 as the basin's principal water resources comprehensive planning agency. The Upper Missouri Subbasin, approximated by county lines for the purposes of the plan, represents the Montana portion of the study area, excluding the Yellowstone River Basin.

Estimates for present and projected water supply and utilization were based upon Montana estimates of withdrawal and consumption, data contained in the 1971 Missouri Basin Comprehensive Framework Study, and supplemental information provided by federal agencies.

Municipal water use was estimated by multiplying 1970 per capita use rates as estimated by the Geological Survey (Circular No. 676, 1970) times the 1975, 1985, and 2000 population projections for central systems services (USDA), assuming per capita use rates and consumption would remain constant over the projection period. Rural domestic water use estimates were projected by the U.S. Department of Agriculture.

Water demands for manufacturing were projected by the Bureau of Domestic Commerce of the U.S. Department of Commerce under the following assumptions:

1) Manufacturing water demands are related directly to product output and have no direct relationship to employment or population;

2) OBERS constant dollar earnings as an estimate of gross product would serve as a proxy for production;

3) the key parameter is gross water demand; and

4) consumptive use increases proportionately with growth of the manufacturing sector.

The Bureau of Mines, U.S. Department of Interior, computed withdrawal and consumptive water uses for mining (metals, nonmetals, and fuels). Mining earnings estimates based on OBERS series E projections were used as a proxy for mining production levels.

To project crop irrigation, the U.S. Soil Conservation Service developed monthly and annual irrigation water use coefficients, estimating crop consumptive irrigation requirements. Estimates were applied to acreage projections to provide monthly and annual irrigation demands. The estimates represent dry year (2 out of every 10 years) requirement values.

Livestock water use was projected by the SCS by multiplying current water use for various livestock types times the projected levels of livestock production from OBERS (1972).

The Bureau of Power of the Federal Power Commission, now the Federal Energy Regulatory Commission, estimated current and future power generation and related water requirements. The bulk of future electric generation was assumed to be from fossil-fuel and nuclear steam-electric plants. Projections to 1985 were based on historical trends, power supply area analysis of energy production and demand levels, and OBERS series E projections for population and economic activity. Projections beyond 1985 were based on OBERS series E projections with no power supply area analysis.

Summary of Projections. Table 23 summarizes the projected water withdrawals and consumptive use for the Upper Missouri Subbasin of the Missouri River Basin Water Resources Plan.

TABLE 23. PROJECTED WATER WITHDRAWALS (WD) AND CONSUMPTIVE USE (CU) FOR THE UPPER MISSOURI RIVER BASIN, MONTANA

	(1,000 acre-feet)					
	1975		1985		2000	
	WD	CU	WD	CU	WD	CU
Municipal and Industrial	53	27	67	34	74	37
Rural Domestic	10	10	7	7	6	6
Self-Supplied Manufacturing	19	2	23	3	33	5
Mining	20	5	20	5	23	6
Irrigation	6,920	3,462	7,768	3,999	8,617	4,540
Livestock	21	21	38	38	51	51
Steam Electric Generation	0	0	0	0	0	0
TOTAL	7,043	3,527	7,923	4,086	8,804	4,645

Supplemental Water For the Milk River

The 1975 state legislature directed (HB 642) a study of the possibilities of the diversion of water into the Milk River in northern Montana. The DNRC in cooperation with the U.S. Bureau of Reclamation completed the study Supplemental Water for the Milk River in 1977 as a result of that request.

The Bureau of Reclamation studied the water supply in the Milk River Basin and determined that an average annual water shortage of 38,000 acre-feet occurred during the ten-year period from 1964 to 1973. If Canada had used its legal allotments of water in the basin, the average annual shortage would have been 49,200 acre-feet. Four possible routes for diversion from the Marias River, Missouri River, and Fort Peck Reservoir were analyzed in the study, and two were recommended for further study. Whether or not one of these two routes will be constructed is uncertain. The construction of one canal would result in an estimated development of 24,000 acres to full service plus supplemental service to 108,140 water-short acres. The other canal would result in estimated development of 19,000 acres to full service and supplemental services provided to 53,200 water-short acres. No other projections for future water use were presented in the study.

Poplar River Basin Study

On February 21, 1975, the Saskatchewan Department of the Environment authorized the Saskatchewan Power Corporation to construct a 32,000 acre-feet reservoir on the East Poplar River to develop thermal power from lignite coal deposits in the Poplar River Basin in Canada. Because the Poplar River is an international river, the International Joint Commission instructed the International Souris-Red River Engineering Board to study the Poplar River Basin in order to make recommendations on apportionment of waters in the basin between Canada and the United States.

Two levels of probable future demands for water in the Poplar River were estimated in this study:

1) Future intents to use water by 1985; and
2) possible future uses of water based on known resource capabilities.

Methodologies differed outside and inside the Fort Peck Indian Reservation. Outside the reservation, estimates were based on landowner interviews, detailing future plans, acreages involved, and timing of developments for irrigable lands near streams, and on general estimates made by the DNRC. Within the reservation, development of Indian water supplies was estimated by Morrison-Maierle, Incorporated, for the Bureau of Indian Affairs. Firm water supply was estimated, based on storage and streamflows. Irrigable acreage was estimated based on field examinations, and data from the DNRC, SCS, and Bureau of Reclamation.

Domestic water requirements were estimated by linear projections of historical trends.

The only industrial water use projected is 7,000 acre-feet per year for a potash mine proposed by Farmers Potash Company, a joint venture of Burlington Northern, Incorporated, and C.F. Industries, Incorporated, located at the confluence of the East and Middle Forks of the Poplar River.

Not all of the projected water uses can occur with present water supply. This fact was recognized and presented in the study. Table 24 summarizes the projected uses for the Montana portion of the Poplar River Basin. Canadian use intents by 1985 amount to 9,100 acre-feet. An additional 66,500 acre-feet of possible future use has been identified for industrial and municipal purposes in Canada. This development can only be possible, however, if no other development of water use in the basin occurs, or if water is imported.

TABLE 24. PROJECTED FUTURE WATER USE DEMANDS IN THE POPLAR RIVER BASIN, MONTANA

(Acre-feet)	Use Intents by 1985	Additional Possible Future Use
Domestic	420	2,400
Irrigation	64,900[a]	
Municipal	120	
Industrial	7,000	
TOTAL	72,400	2,400

[a]Can only occur if all other development is excluded.

ANALYSIS

The Missouri River Basin Water Resources Plan relies heavily on the projections, assumptions, and methodology of the Framework Report (Missouri River Basin Commission, 1969). A critique of the Framework Report will thus serve as a critique of both. The following quotations from Volume 1 of the Framework Report express the viewpoint of the study:

> A comprehensive framework plan is a broad guide to the best use or combination of uses of water and related land resources of the basin to meet foreseeable short- and long-term needs for those resources. Need, as defined in this study, is the difference between the demand for specified goods or services and the productive capability of the basin's resources at a specified time.....(p. 109)
>
> The framework projections represent a level of demand consistent with the national economic efficiency objective.....The final value of need reflects a judicious mix of the multiple objectives representing trade-offs where necessary to best serve the well-being of all the people.....(p. 110)
>
> The national objectives for future agricultural development needs are determined by comparing the projected capability of the soil and water resources to produce agricultural products with the projected future requirements for those products.....(p. 111)

Such a point of view implies that supply and demand are completely predetermined and irresponsive to factors such as price, production costs, substitutes, income, and foreign trade. Projected demands are interpreted as levels of provision of goods and services necessary to the well-being of the American public. The implication of this interpretation is that supply must meet demand, regardless of cost.

The report asserts that the projections interpret economic efficiency as an objective. This assertion is false. Economic efficiency is not met by forcing supply outward to meet mythically vertical demand curves. Economic efficiency means that goods and services are produced to the level where the marginal costs of the last units sold just equals the marginal values to the consumers of those goods and services. It also means that resources are allocated to the various forms of production in such a way that the marginal value to each productive process is just equal to the marginal cost of employing each resource in that particular process.

Several of the projections made in the Framework Report seem to be quite high. For example, the study estimated over 150,000 acre-feet of water would be diverted per year by 1980 for thermal-electric power generation. To date there are no thermal-electric generating plants in operation or under construction in the Upper Missouri Basin. As no applications for such plants have been received by the DNRC, it is quite certain that there will not be the large amount of development projected in the study. Also, about 97 percent of the projected diversions are for once-through cooling-type plants. None of the recently constructed thermal-electric plants in Montana utilize flow-through cooling, nor are any proposed plants of this type. Therefore, the projection that nearly 143,000 acre-feet will be diverted by the year 2000 for this means can be eliminated as a possibility.

Beyond 1980 there are three plants under consideration by utilities in Montana for development in the Upper Missouri Basin. One plant, a 440 megawatt generating unit, is proposed for location near Circle, with a possible optional site at Glasgow Air Force Base. Another, a 300 megawatt unit, may be located near Great Falls, though the actual location of this unit and the third, another 300 megawatt unit, is quite uncertain. Regardless of the exact location of these plants, it is quite certain that there will not be an increase in diversions for thermal-electric power generation of 444,560 acre-feet by 2000.

The Missouri River Basin Water Resources Plan made an adjustment in the Framework Report thermal-electric projections by simply projecting zero steam-electric generation in the Upper Missouri until 2000. This projection likely understates the true picture, as Montana Power Company and Burlington Northern plan to develop plants in the basin that would produce 1040 megawatts.

The study projections for irrigation acreage rely on OBERS projections for livestock, interpreting OBERS so that feed requirements to meet the projected levels of livestock production come from within the basin. The acreage estimates are likely to be biased upwards because of such factors as recent increases in beef import quotas, the inverse relationship between demand and rising beef prices, and substitution of fish, pork, and poultry for beef.

"Best Guess" Estimate

It seems reasonable that steam-electric generation will increase by approximately 1050 megawatts by the year 2000, and that wet-tower type cooling will be the technology used. This implies an increase in depletions due to thermal-electric power generation of about 15 to 20,000 acre-feet per year. Other projections are as follows: irrigated acreage will increase 200,000 to 300,000 acres, with associated increased depletions of 400,000 to 600,000 acre-feet per year, and municipal, industrial, and rural domestic water consumption will increase 10,000 to 20,000 acre-feet per year by 2000.

Due to the reconnaissance nature of the projections and the methodological problems with the studies that made the projections, these "best guess" estimates are only plausible guesses, have an extraordinary margin for error and do not provide a reliable basis for identifying future shortages and problems.

Water Supply

Figure 7 presents the 50th- and 90th-percentile outflows of the Missouri River near Culbertson. The hydrograph for the Missouri does not have the same general shape as most Montana rivers due to regulation of flows at Fort Peck Dam.

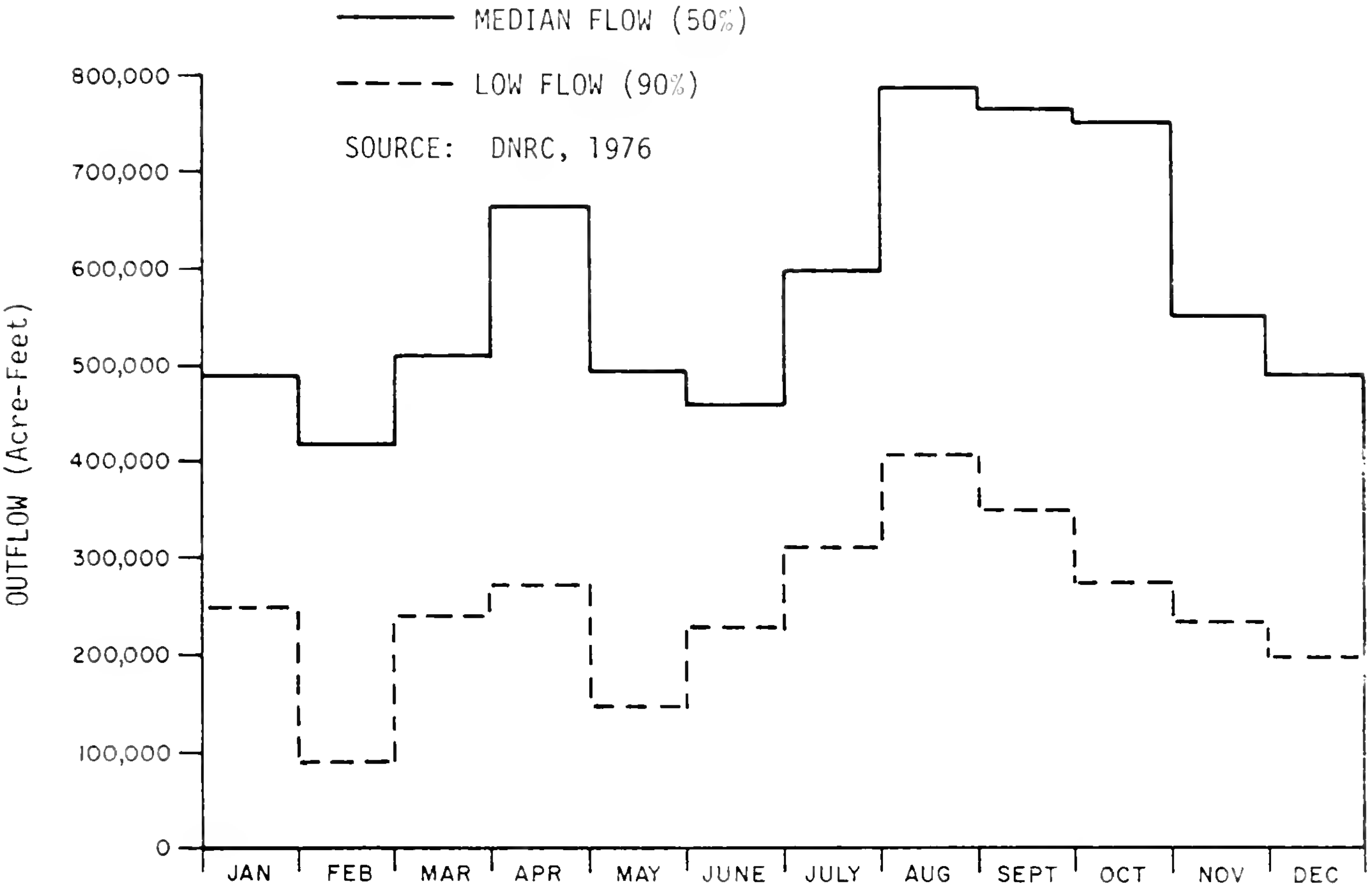

FIGURE 7. MISSOURI RIVER AT CULBERTSON

Table 25 lists the major tributaries of the Missouri River in Montana, their average annual discharges into the Missouri, and percentage contributions to total outflows from the state.

TABLE 25. DISCHARGES AND PERCENTAGE OF TOTAL OUTFLOW BY TRIBUTARY IN THE MISSOURI RIVER BASIN

Stream	Average Discharge (Acre-Feet)	% of Total Outflows
Missouri near Culbertson	7,607,000	100.0
Gallatin near Logan	757,800	10.0
Jefferson near Sappington	1,550,000	20.4
Madison near McAllister	1,271,000	16.7
Sun near Vaughn	534,000	7.0
Marias near Chester	669,400	8.8
Mussleshell near Mosby	192,000	2.5
Milk at Nashua	511,500	6.7

BASIN SUMMARY

Projections for increased consumptive use of water in the Missouri River Basin total 425,000 to 640,000 acre-feet per year by the year 2000. Without additional storage, the regions in which this development can occur are limited. Several tributaries in the basin have current as well as potential problems related to over appropriation of existing water resources, including but not limited to the Milk, Musselshell, Sun, Teton, Dearborn, Smith, Madison, Gallatin, Jefferson, and Big Hole Rivers. Serious dewatering of some stretches of some streams occurs due to irrigation depletions. Streams such as the Sun and Teton Rivers also frequently flood during high spring runoffs.

Water quality is often adversely affected by low flows, sediment production and nutrient runoff from agricultural land, timber harvest, and recreational development. Appropriations of water between Canada and the United States can affect flow patterns and water quality in the Milk and Poplar Rivers. Competition for water between irrigators and hydropower create potential conflicts. The adjudication of instream rights for hydropower may seriously limit water availability for diversionary and consumptive uses, particularly agriculture. Indian water rights, once adjudicated, may also limit water availability on the Milk, Poplar, and Lower Missouri rivers and on Porcupine, Beaver, and Big Muddy creeks.

The Army Corps of Engineers is recommending further study of a proposed project to install two additional hydropower units at Fort Peck Dam with a capacity of 92.5 megawatts each and to construct a reregulating dam eight miles from Fort Peck Dam to smooth the downstream fluctuations resulting from the conversion to peaking operations at Fort Peck. The eight-mile reregulation pool would eliminate the fishery and inundate the dredge cut lakes in that area. A total of 1,290 acres of privately owned land would be flooded, and some opposition to this by the current land owners has been expressed. Whether or not the project is undertaken depends mainly upon the results of further feasibility studies and authorization for construction by Congress. Tentative scheduling indicates that if authorization is granted, construction could likely be initiated by 1986. This project, like the Libby Reregulation project, poses a potential conflict between Montana's environmental concerns and the Federal government's power production programs and policies.

VI. PROBLEMS, POLICY OPTIONS, AND IMPLICATIONS

Water availability will generally not be a physical constraint to continued economic growth in Montana. There are drainages in the state with localized water shortages, especially in the late summer months, including but not limited to the Powder, Tongue, Bitterroot, Madison, Gallatin, Jefferson, Big Hole, Smith, Dearborn, Sun, Teton, Milk, Musselshell, and other rivers. The seasonal shortages in these rivers and others will probably become more noticeable as all valid water rights claims are adjudicated. All available water is appropriated to users during water shortages and is no longer freely available to new appropriators. The opportunity cost of appropriating water in a water-short basin region is therefore greater than zero to new appropriators. An individual or firm that desires water in such an area has five options: (1) relocate to where water is always freely available, (2) store water or buy stored water, (3) purchase water from someone with a reliable water right, (4) get along without water, or (5) persuade the government to give him someone else's water through condemnation procedures or preference systems.

Basically, there are several policy options that can be implemented in water-short areas to deal with water allocation problems: 1) permit market transfers of water and water rights; 2) construct storage and/or aqueducts; 3) adopt nonprice rationing or allotment measures; 4) mandate forced transfers through preference systems; 5) remove subsidies to water users; 6) enforce water rights more effectively and cut off new permits for water use. These options will be described briefly and analyzed in this section of the report.

MARKET TRANSFERS OF WATER RIGHTS

Under current state laws, water rights are appurtenant to the land on which the water is used. The use right passes with a conveyance or transfer of the land, unless specifically exempted, with no loss of priority. A proposed change in the place of diversion, place of use, purpose of use, or place of storage, or severance and sale of all or part of an appropriation right to other lands or purposes requires prior approval by the Department of Natural Resources and Conservation. The department must approve a proposed change unless it determines that the change might adversely affect the rights of other persons. However, an appropriator of more than 15 cfs may not change the purpose of use from agricultural to industrial.

If the department determines that a proposed change may adversely affect other rights, notice of the proposed change must be posted according to state law (Section 89-881, R.C.M. 1947). If a valid objection is then filed by a person whose rights may be affected, a hearing must be held prior to approval or denial of the change. The department may then approve the change subject to the terms, conditions, and limitations it considers necessary to protect the rights of other appropriators (Section 89-892-893, R.C.M. 1947).

Unless the original purpose of the water right was to appropriate water for sale or lease to users, there is no authority under Montana Law which authorizes a water right holder to sell or lease excess water to another user. Water rights are use rights, not rights of ownership, as indicated in the following quotation: "An appropriator of water does not become the owner thereof but only of the right to use it; he may not sell the water to another to be used by the purchaser when not in use by the appropriator" (Galahan vs. Lewis, 105 Montana 294,300, 72 p. 2d 1018).

Water rights transfers, use rentals, and changes of use usually entail effects on third party users. The protection of these third parties, or vested interests, has led to restrictions that tend to hamper market transfers. Present transfer procedures do not lead to an efficient allocation of water resources, except fortuitously. Neither is it evident that the permission to transfer without regard to protection of other rights would result in an efficient allocation. The external, or third party, effects of interest are related to changes in return flow and changes in water quality.

Irrigation, as the dominant use of water, faces increasing competition from domestic, industrial, and recreational demands. Continued growth of regional income in Montana could be facilitated by modification of the laws restraining or prohibiting water rights transfers so that water can move from low value uses to high value uses. In the 1973 report to the President, Water Policies for the Future, the National Water Commission came to the following conclusion: "The principal opportunity for reallocation of water through voluntary transfers would seem to be from relatively low-value agricultural uses to higher value municipal and industrial uses." (p. 265)

Almost any water right transfer or change in the point of diversion in a water-short basin will change the return flow pattern and pose a potential loss to someone. Therefore, most transfers are restricted to the amount of historic consumptive use as a general rule. Thus, the saleable and transferable extent of ownership is different from and less than the extent of ownership for continuation in the present use.

The possibility of purchase and sale of return flows would take into account the full use of water in its present use and the full anticipated use at the new diversion. Such an arrangement would meet the requirements for efficient allocation of water. However, the feasibility of a transfer procedure allowing a buyer to sell new return flows created downstream depends upon the availability of certain hydrologic data. These data involve a knowledge of the underground geology, transmissibility of the aquifer, the water table level, etc., so that the flow from deep percolation from irrigation could be traced to reappearance as streamflow or as stored water in an underground basin. Such knowledge is costly and difficult to come by. In streams where pollution is a problem, measurement of return flow pollution from different uses would also be necessary.

The problems involved with developing water transfers and administrative procedures to better facilitate such transfers are immense and costly. Nevertheless, there is a procedure to facilitate water transfers that is not so costly, nor difficult to achieve, especially within individual water-supply agencies in the state. The system is coming to be know as "water banking," and was used during California's 1977 drought.

Water banking is similar to the banking of money in a financial institution. It involves the purchase of water from some users by a governmental agency and its resale to other users. Users who deposit their water in the bank are paid for its use, and users who withdraw water from the bank must pay for it. All water deposited during one period is withdrawn during that same period, used, and never replaced. The agency operating the bank, like a financial institution, acts as an intermediary - arranging the transactions, keeping records, handling the flow of money and water, and compensating third parties.

The price of bank water will move to that level at which the water that is supplied will exactly equal the water demanded at that price. The higher the price of bank water, the greater the incentive will be to make deposits and the less the incentive to make withdrawals. Users will deposit water in the bank if the money is worth more to them than the water. The comparative worth of money and water for any particular user depends on such factors as the availability and the price of various agricultural products, and the desire for or availability of money.

The individual's decision to deposit or withdraw water is purely voluntary and will not affect his initial annual water allotment, as determined by the priority of his water right, the streamflow levels, and the allocation system established. Water banking will allow a user to use his allotment, deposit some or all of it in the bank, or purchase additional supplies. If a farmer does not wish to participate in water banking, he will receive his regular allotment as if water banking did not exist. A user making withdrawals receives his usual allotment of water plus the withdrawals.

To establish water banking, the water codes would have to be amended to make short-term and long-term water transfers possible and to permit each water-supply agency in the state to operate a water bank if it chose to do so. No agency would be required to participate, though local, regional, and statewide water-supply agencies would all be eligible. Any water-banking transaction would need to be defined as a "beneficial use" to protect against the loss of water rights due to the lack of use by the water right holder, and provisions should be made for third party charges or compensation for external benefits or costs.

Benefits from establishing water banking in the state would be numerous. Participating users would receive direct benefits due to the mutual gains from exchange. Water conservation incentives would be created and unproductive water could be transferred to productive uses. The current system provides incentives to waste water so that a water right will not be classified as abandoned. The water banking system is flexible. As the value of water in alternative uses changes, the allocation of water among these uses will change automatically in response to economic incentives. Planning would also be facilitated since the feasibility of moving water from places of relative surplus to places of relative shortages during a drought would be increased. However, administration would be expensive because impacts on third parties must be considered. The system is only valuable in fully appropriated streams with well-developed methods for hydrologic analysis. In most Montana streams unappropriated water is available and water banking is likely to cost more than it is worth.

Water is wealth, and it has been historically distributed on a first-come, first-served basis. Neither the process nor the result has been especially "just" or "unjust". The current system has not resulted in economically efficient allocations of water, however, and this will become of increasing importance as competition for water grows.

Water banking recognizes the right of water users to capture the wealth implicit in their historic and customary water allotments, while letting the water itself be used by others. If individual landowners with abundant water rights deposit their water in a water bank in exchange for money, it may be asked, "Is it just that they should profit?" The only reasonable answer is that it is neither just nor unjust, but if they are allowed to bank it, water will be used more productively.

The argument has been presented many times that farmers are incapable of competing financially with industry for valuable water resources, yet an expansion of irrigation for agriculture is necessary. The argument often is carried further, asserting that food is the number one problem in the world. The emotional appeal of this position is apparent. However, if the products of irrigated agriculture were so "necessary" in the American economy, the value of irrigation water would be competitive with industrial prices for water. Farmers would not have any problems whatsoever competing financially with industry for water.

Even though the argument that industry would "take all the farmers' water" if transfers were allowed seems to fall under its own weight, it is a widely held view. The problem with such reasoning is that it not only leads to gross misallocations of increasingly scarce water resources, but it also eliminates the opportunity for many farmers to improve their financial position by capturing the wealth implicit in water rights. An example will illustrate.

Farmer Brown has 1,000 acres of irrigated alfalfa hay that yields on the average three tons per acre per year. He holds water rights to divert 3,000 acre-feet per year, and the normal depletion rate is 2,000 acre-feet, or 2 acre-feet per acre per year. Down the river 5 miles is located an industrial plant that wishes to purchase water from Brown. The plant values the water at $100 per acre-foot, but hopes to buy it at a much lower price.

Before Brown began to irrigate his hay, the yields only averaged 2 tons per acre. He figures the hay is worth about $45 per ton. If he decides to, and is allowed to, sell the historical consumptive-use amount of water to the industry, his total yield loss will be 1,000 tons per year, valued at $45,000. He determines that his use right is therefore worth $15 an acre-foot for the three acre-feet per acre appropriation.

Farmer Brown decides that he will sell water to the plant for $50 per acre-foot and the industry agrees. Is Brown better off with or without the use of his water? He sells 2,000 acre-feet per year for $50 an acre-foot, receiving a total of $100,000 per year from the industry. He loses $45,000 worth of crop value because he no longer irrigates. Clearly Farmer Brown has gained $55,000 in annual income, in addition to the money he has saved by not irrigating.

The point that this simplistic example illustrates is that legislative restrictions to water rights and water use transfers, while operating under the guise of protecting agriculture and agricultural interest, actually injure those same interests by limiting choice and eliminating much of the wealth implicitly contained in water rights in Montana. Growth and development and optimal use of water resources are thus restricted by these legal barriers to market activities.

CONSTRUCTION OF STORAGE OR AQUEDUCTS

The principal means of increasing available water supplies is through reservoir storage. Increasing storage capacities by building reservoirs does not create new water, but it makes more water available for use when it is most beneficial, such as irrigation during the late summer months when natural flows are lowest. Storage reservoirs and the water stored can also be utilized as recreational facilities, hydropower generation sites, cooling ponds for thermo-electric generating processes, for flood control, municipal, and industrial water supplies, or other useful purposes. Costs involved in creating reservoirs include the value and opportunity cost of land inundated, construction costs, possible damages to instream and riparian habitats, and the value of the streamflow for other uses without the reservoir. The major consideration in planning to increase the storage capacity along Montana's waterways is whether the sum total of benefits accrued from additional reservoirs exceed the costs incurred.

Table 26 shows the major reservoirs in the state. Table 27 shows potential reservoirs that could be built with storage capacities greater than 100,000 acre-feet. Many of the potential reservoirs will never be constructed due to various political, economic, and environmental reasons. For example, in 1974 the Montana legislature passed a resolution stating that authorization or construction of Allenspur Dam on the Yellowstone River above Livingston is not in the interest of the citizens of Montana. Coupled with this is the fact that the 1976 updated benefit-cost ratio for Allenspur calculated by the Bureau of Reclamation is less than one. This means that the annualized costs of constructing the dam are greater than the annualized benefits, disqualifying the dam as a national economic development project. These factors combined present a dim future for the construction of Allenspur Dam.

TABLE 26. TOTAL STORAGE IN MAJOR MONTANA RESERVOIRS

NAME	STREAM	(ACRE-FEET)	ACTIVE STORAGE	PURPOSES[a]
Yellowtail	Bighorn River	1,375,000	1,356,000	I, FC, P, FW
Flathead Lake	Flathead River	1,791,000	1,219,000	P
Hungry Horse	South Fork Flathead	3,468,000	2,982,000	FC, I, P
Lake Koocanusa	Kootenai River	5,850,000	4,965,000	FC, P, FW
Canyon Ferry	Missouri River	2,051,000	2,043,000	FC, I, FW, P
Fort Peck	Missouri River	19,410,000	13,915,000	M, FC, P, I
Tiber	Marias River	1,368,000	762,000	FW, I, FC, M

[a]Purposes: Irrigation - I, Flood Control - FC, Fish and Wildlife - FW, Power - P, Municipal -M, and Livestock - L.

TABLE 27. POTENTIAL RESERVOIRS WITH STORAGE CAPACITIES GREATER THAN 100,000 ACRE-FEET

YELLOWSTONE BASIN

SITE NAME	STREAM	PURPOSE	STORAGE(ACRE-FEE
Absaroka	Yellowstone River	I, T, P	892,000
Allenspur	Yellowstone River	T, P, I	4,012,000
Lower Canyon	Yellowstone River	T, P	1,384,000
Wanigan	Yellowstone River	I	1,320,000
Yankee Jim	Yellowstone River	T, P	280,000
Buffalo Creek	Buffalo Creek	C, R, I, F, W	110,000
Cedar Ridge	Starved to Death Creek	C, R, I, F, W	126,000
Custer	Bighorn River	T, P	501,000
Lissa	Yellowstone River	I	1,600,000
Moorhead	Powder River	I, P, F, T, W, R, D	1,150,000
Sunday Creek	Yellowstone River	C, R, I, F, W	539,000

SOURCE: Montana Water Resources Board, Summary of Potential Projects in Montana (Inventory Series No. 9), June 1969.

MISSOURI BASIN

Beaverhead Rock	Beaverhead River	I	117,400
Ennis	Madison River	I	588,100
Fishtrap	Big Hole River	I	179,100
Lower Basin	Gallatin River	P	292,900
Madison Reservoir	Madison River	I	772,000
Reichle	Big Hole River	P, I	907,200
Spanish Creek	Gallatin River	I	210,000
Titan	Big Hole River	I	151,900
Buckingham	Smith River	I	139,600
Fort Logan	Smith River	I	105,000
Glendale	Crow Creek	I	154,400
Truly	Smith River	I	104,100
Ulm	Missouri River	P	237,800

TABLE 27. (continued)

SITE NAME	STREAM	PURPOSE	STORAGE(ACRE-FEET)
Badger Creek	Badger Creek	I	[illegible]
Carter	Missouri River	P, N, T	2[illegible]5,100
Castle Reef	Sun River	I, T	422,000
Lower Sun Butte	Sun River	I, T	312,000
Lowry	Sun River	I, T	370,000
Marias River	Marias River	I	82[illegible]
Two Medicine	Two Medicine Creek	I	18[illegible],500
Upper Sun Butte	North Fork Sun River	I, T	260,000
Pear Paw	Missouri River	I	210,600
Eliad	Missouri River	T, N, P	3,037,000
Rocky Point	Missouri River	T, N, P	1,112,800
Battle Creek	Battle Creek	T	110,000
Beaver Creek	Beaver Creek (Phillips)	I, T	371,000
Lower Big Muddy	Big Muddy Creek	I	5,200,000

COLUMBIA BASIN

SITE NAME	STREAM	PURPOSE	STORAGE(ACRE-FEET)
Atkins	Rock Creek	I	248,000
Finlen	Rock Creek	I	123,000
Lay	Rock Creek	T, I, P, R	248,000
Lolo Creek	Lolo Creek	I, P	135,000
Myrick	Clearwater River	I	131,000
Ninemile Prairie	Blackfoot River	P, T	1,000,000
Ovando	Blackfoot River	P, I	154,000
Sapphire	Rock Creek	I	101,400
Ferril	Blackfoot River	T, P, I	408,000
Upper Ovando	Blackfoot River	I	216,000
Buffalo Rapids No. 2	Flathead River	P	121,000
Buffalo Rapids No. 4	Flathead River	T, P, R	868,000
Eddy	Clark Fork River	P	160,000
Kerr	Flathead River	T, P, I	6,000,000
Knowles	Flathead River	T, P, R	5,200,000
Paradise	Clark Fork River	T, P, R	6,400,000
Perma	Flathead River	I	4,750,000
Quinn Springs	Clark Fork River	P	135,000
Thompson River	Thompson River	I	335,000
Wear	Bull River	T, P	149,000
Big Rock	Flathead River	I, P, T	6,000,000
Flathead Lake Outlet	Flathead River	T, P	690,000
Glacier View	Flathead River	T, P	3,160,000
Smokey Range	North Fork Flathead	T, P, R	1,650,000
Spruce Park	Middle Fork Flathead	T, P, F, W	410,000
Stillwater	Stillwater River	I	150,000
Long Meadows	Yaak River	P, C, R, F, W	726,000

[a] Code Purpose: T-flood Control, I-irrigation, R-recreation, U-municipal, P-power, N-navigation, X-miscellaneous, F-fish, W-wildlife, A-pollution abatement, C-industrial, S-stockwater, D-domestic, and G-mining.

RATIONING AND CONSERVATION MEASURES

The existence of a water "shortage" in a region can mean several things. Often, a shortage indicates an absolute stringency of supply (water is "short" in Death Valley), or sometimes any reduction of the supply to which people have been accustomed (last year's drought created severe water "shortages."). What a shortage actually implies, however, is a situation in which more water is demanded than is being supplied at the going price. The problem that must be solved in a water shortage, then, is how to ration, or allocate, the available water to the competing demands. The economics of the problem indicate that water should be alloted to each user in the amount that results in the marginal value (value of the last additional unit) of water to him just equaling the marginal cost of water for his particular use. This may be considered as one goal in water allocation: economic efficiency. Another goal might be equity, or fairness, so that all users are given equal treatment in water allocation decisions.

The basic working of the "first in time is first in right" appropriation system in Montana contains an implicit rationing scheme for water short years. When water is short in a basin, the users with the most recent water rights are appropriated no water, while senior appropriators receive their usual allotments. During critical months in low flow years, large differences can occur between the marginal value of water for different appropriators. For example, some farmers with senior irrigation use rights will receive the full crop requirement, so that the last unit of water to them has a low marginal value, while junior appropriators, desperate for water, value an acre-foot at up to $200. Clearly, this situation can result in extremely inefficient allocations of water in dry years in water short basins.

One seemingly obvious remedy for a shortage is to raise the price of water. For example, a municipal water-supply enterprise might increase the price of water it sells in order that the quantity demanded will fall. Consumers would use water up to the point where individual marginal values in use just equalled the market price. Thus, the value of the last unit of water used by each consumer would be the same in terms of dollars, or opportunities foregone, and the efficient water allocation would result if the price were set so that the quantity of water demanded just equalled the supply. However, such a system may be of limited effectiveness as a water conservation measure in very short-term droughts or water shortages. Consumers are much less responsive to price changes in short-run periods than in the long-run, especially when their expectations lead them to believe that a price increase is only temporary. Another criticism of using price as a rationing mechanism for water is that water is of purportedly unique importance to the well being of everyone. The poor, or low-income groups of people, are therefore forced to bear a disproportionate share of the burdens resulting from water shortages with price rationing. Also, as mentioned earlier in this report, PSC regulation of municipal water rates may prohibit municipal pricing strategies as conservation methods.

Another form of rationing that can be implemented is the "share and share alike" concept common in independent ditch companies. This means that all users are allotted water on an equal basis, and each must share part of the burden of the water shortage. Municipal systems also commonly implement water allotments, or quotas, to cope with short-term shortages, usually accompanied by stiff fines or penalties for overuse. The main advantages of such a conservation scheme are a certain sense of "justice", or "fairness," in that everyone receives equal allotments of water, and the fact that price rationing may be difficult to implement in short-term periods of water shortage, or drought. The major weakness of such a system is that though it may seem "fair," it is usually inefficient. Generally some water users would be willing to pay more for additional water while others would be willing to sell part of their allotment, or would be willing to use less to escape from paying the price that higher-valued uses would command. Unless non-price rationing measures accurately reflect market preferences, such measures will not result in efficient water allocation.

PREFERENCE SYSTEMS

A preference system for water rights implies some uses are preferred over others, and the preference of use is reflected by priority of appropriation right. For example, Senate Bill 359, defeated in Montana's 1977 Legislative Session, defines the following order of classes of preferred beneficial uses: (a) domestic use, including municipal domestic uses; (b) agricultural, irrigation and stockwater uses; (c) a minimum flow for recreational, fish and wildlife, and water quality uses; (d) municipal use other than domestic; (e) industrial use by means of storage; (f) industrial use by means of direct diversion; (g) recreational, fish and wildlife, and water quality uses; and (h) all other uses. Within each class priority is determined by the date of appropriation.

There are basically two types of preference systems that can be implemented. One type affects all appropriations subsequent to the effective date of the act implementing the preference system, with no primary effect on prior appropriators. The other gives preferred uses the power to condemn and seize water rights held by a less preferred use, usually requiring compensation or consent of the less preferred right holder. The system proposed in SB 359 contains characteristics of both types; only appropriations subsequent to the effective date of the act would come under the provisions of the act, and condemnation of a less preferred use right requires compensation or consent of the right holder.

It is interesting to note that a preference system in Montana would actually have no effect on municipal uses since Section 11-966, R.C.M. 1947, subsection (3) grants all towns and cities the power of eminent domain to "procure and appropriate water rights and title to the same, and the necessary real and personal property to make said rights and supply available, by purchase, appropriation, location, condemnation, or otherwise."

Because of the compensation clause, a preference system would be impractical to implement. There is very little chance that a farmer would value the water appropriated for a less preferred use, particularly an industrial use, enough to be willing to pay the just compensation, in other words the value of the water to the less preferred use right holder, plus the costs involved with the administrative process. In most cases, the value of water for industrial use is greater than the value for agricultural use. The Department of Fish and Game and the Department of Health and

Environmental Sciences are not likely to be willing nor able to undergo the high costs of establishing firm minimum flow quantities necessary for the absolute maintenance of fish and wildlife habitat or water quality which include compensation of less preferred use right holders, and the costs of condemning or otherwise appropriating industrial, municipal (non-domestic), or other water. As a result, it seems evident that such a preference system would be little more than an administrative headache.

There are critical questions that must be answered before such a preference system is initiated in Montana:

Do social considerations make reservation of water for irrigation "better" than industrial developments, regardless of the relative dollar benefits? Are attempts to discourage industry desirable? What are the trade-offs between municipal, agricultural, and industrial uses for water; between consumptive and instream uses?

Presently there is not enough information available to answer these questions. Accurate data would be necessary relating the true social costs and benefits from specific irrigated agriculture products, industrial products, recreation values, fisheries and habitat values, water use and consumption rates, water quality impacts, and so forth before a judgement could be made. Though such data are not available and would be quite costly to obtain, it is fairly clear that each and every domestic use for water does not outvalue each and every agricultural use, and each and every agricultural use does not outvalue each and every industrial use, etc. Trade-offs between the competing uses for water exist, but preference systems carry no provisions for those trade-offs.

A state legislative committee determined last year that preference systems in Montana would be politically and economically infeasible. A study of preferential uses in those states which had a system in operation, was performed by the late Senator Smalley of Oklahoma in 1962 (then a law student at the University of Oklahoma) under the supervision of Joseph F. Rarick, David Ross Boyd Professor of Law, University of Oklahoma.

The study showed that generally there was dissatisfaction with preferential use provisions in most of the states that had adopted the scheme.[9]

Preference orderings are typically based on perceived average or total values of water to various uses rather than marginal values. This is evident when domestic uses are placed at the top of the preferred use list. People need at least a certain amount of water in order to live, and therefore value that initial amount quite dearly. However, water used for relatively luxurious purposes in the home are not valued nearly as much by many domestic users, while industry generally values water quite highly.

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[9]Cited in "Oklahoma Water Law, Stream and Surface Under the 1963 Amendments", reprinted from Oklahoma Law Review, Vol. 23, No. 1 (Feb. 1970) p. 47. Also, personal telephone conversation July 5, 1978 with Professor Rarick.

Preference systems appear to be designed for their political clout. By securing water for municipal and agricultural uses over industrial uses, politicians can lead more people to believe that government is looking after their interests. Although this makes sense in the political sphere, it does not appear to be the type of system that is optimal economically.

Preference systems and water transfers would almost necessarily have to be mutually exclusive. For in a system where water transfers work, a preference system allocates money and not water. Preferred users would sell their valuable priorities to less preferred users if the money was worth more than the water. The preference system establishes priority and security of water right, but the market allocates the water to its most valuable uses. Thus a preference system intended to allocate water would only be useful when transfers are costly or illegal.

If all waters in a stream are appropriated, preference systems that subject only the subsequent water rights to a preference ordering structure create windfall gains to holders of senior water rights for less preferred uses. Such a right is relatively more secure and reliable compared to rights for the same use appropriated after preferences are established. Dependability and security are valuable characteristics in a water right, particularly for an industrial use. This value can be capitalized into the value of the appurtenant land, or the value of the severable and saleable water right, and may result in sizeable wealth transfers to the holders of such senior rights for less preferred uses.

Economically, preference systems are not a very attractive means of dealing with problems resulting from water shortages. Available evidence indicates that if the costs of administration are high, compliance is seldom voluntary on the part of water users losing the right to a less preferred use, and the overall impacts on actual water use are slight. This seems to clearly imply that the costs of such a system far outweigh the benefits and that economically optimal water allocation would not result from the implementation of such a system.

WATER RIGHTS ENFORCEMENT

It has been suggested in this report that substantial increases in product value from industry and agriculture could be obtained in water short regions through transfers of water and water rights. Presently there are regions in the state with water supply problems, yet market transfers of water rights seldom occur. One possible reason for this may be that municipalities have relatively secure water supplies due to rights of eminent domain, transfers from agricultural uses to industrial uses are illegal, and the marginal value of one agricultural use is not sufficiently higher than the marginal value of another agricultural use to cover transaction costs. Another reason could be that most streams are not adjudicated and water rights are not well defined nor enforced. These factors combined are likely causes for the limitations to market transfers of water and water rights in Montana. In order for trade to occur, a sound definition of what is being traded is necessary, and the benefits to each party must be greater than the costs.

The question now arises whether water rights should be more strictly enforced so that water theft is prevented during periods of water shortage and the legally correct appropriations of water occur. Before water rights can be enforced, adjudication of the water rights in a stream must be completed. This process is ongoing in the Yellowstone River Basin, but it is long and costly. It has been estimated that at current rates of progress it will take 200 years to adjudicate the entire state. Enforcement is also quite costly, and only valuable in over appropriated streams. There are decreed streams in the state in which water users apply for water rights enforcement occasionally during low flow years. These are generally in water short regions where the costs of enforcement are worthwhile to those who benefit from it. In the rest of the state water is usually easily available and strict enforcement of water rights is not worth the high costs involved. This is likely to remain the case until all water in a given stream is appropriated and the water rights of that stream are adjudicated.

Another problem associated with the uncertainty of available water supplies due to unadjudicated water rights is over appropriation of water in certain streams. Montana laws currently stand written in such language that, in streams like the Milk River, where water shortages are already known to occur, the DNRC is required to issue new water use permits meeting minimum legal requirements even though water is available for the requested use only five years out of ten, sometimes only two years out of ten. To be profitable, irrigation operations generally require adequate water supplies eight years out of ten and other uses require much more dependable water supplies. The only way a new permit holder can obtain enough water in such a situation to be viable is by water theft, which is relatively simple and unnoticeable because it is virtually impossible to determine whose water is being taken by whom. One possible solution to this problem would be legislation granting the DNRC discretionary power to cease issuing new permits at certain levels of streamflow depletion in order to protect the vested interests of existing water rights holders. This could be facilitated by a water rights claims filing process that would allow water rights holders a set period of time to file claims to their water rights. Although this would in no manner constitute adjudication of a stream, it would be valuable information for estimating water use quantities to be compared with historical streamflow levels.

IRRIGATION SUBSIDIES

As discussed briefly in the introductory section on water demand, many farmers receive several types of subsidies for irrigation development. These subsidies reduce the costs of irrigation water to these farmers, increasing the quantities of water demanded for irrigation use. Such subsidies are effective transfers from taxpayers to farmers because the irrigation projects are financed wholly or partially by either state or federal government spending without full reimbursement from the farmers. But, due to the highly competitive nature of agricultural markets, farmers receiving the subsidies tend to earn only normal incomes. Part of the subsidies is passed on to consumers of irrigated agriculture products in the form of lower prices. This is so because water as an input to irrigated agriculture contributes to output and to the cost of farming. Lower costs of water result in lower production costs, increased output, and lower market prices for irrigated agriculture products. Another part of the subsidies goes to landowners, who are not necessarily the farmers, in the form of windfall gains that are capitalized into land values. The remaining part of the subsidies is lost to inefficiency and misallocation of resources.

As water supplies become increasingly scarce due to greater demands and the opportunity costs of additional streamflow depletions rise, one possible means of curbing agricultural demands for water, by far the largest consumptive use, is to eliminate subsidy programs for irrigation development in the state. Such an action would bring the private costs of irrigation water use closer in line with the true social costs. It appears likely that the higher costs of irrigation water would result in substantial reductions in the quantity of water demanded, though actual data on the elasticity of demand for irrigation water is not readily available and extensive research of the subject is beyond the scope of this report. The reason that irrigation water use is probably substantially responsive to water cost is because water is major input to irrigation operations. If the price elasticity of irrigation water were merely -1, a 10 percent increase in water costs would reduce quantities demanded 10 percent. Since 95 percent of the water used in Montana is for irrigation, this 10 percent reduction would nearly triple the amount of water available for municipal and industrial uses.

COAL SLURRYING

The diversion of water for the purpose of slurrying coal across the state line is an illegal use of Montana's water. One reason for this is a reluctance to export the state's water with its energy resources. In addition to the state restriction on coal slurrying out of Montana, there is a question concerning powers of eminent domain contributing to the uncertainty of the future of coal slurrying. One proposed pipeline from Wyoming to Arkansas would cross the tracks of 9 railroads in 49 places. The railroads are reluctant to permit these crossings. Federal legislation granting the rights of eminent domain to slurry pipeline interests failed to pass in Congress in July of this year.

Slurrying pipelines are only competitive with alternative modes of coal transportation when very large tonnages are to be transported medium to long distances from a concentrated mining area to high capacity generating plants. The primary load centers in the demand regions for Yellowstone coal are at distances that favor the slurry pipeline mode of transportation.

The logic of the argument against exporting state water with state coal depends upon the alternative to coal slurrying. Coal transport by rail is obviously much less water consumptive than slurries. However, when the railroads reach carrying capacity, if they do, the alternatives may be thermal-electric generation and transmission or coal gasification within Montana and shipment out of the state. A slurry pipeline would consume 57 percent less Montana water per ton of coal than a typical wet-cooled electric generating plant, and 60 percent less than a typical proposed coal gasification plant.

If demands for Montana coal increase beyond the capacity of the railroads, perhaps coal slurrying should be considered as an alternative means of energy export for Montana.

VII. CONCLUSIONS

The analysis contained in this report up to this point leads to the following conclusions.

1) Generally, existing studies on water use in Montana did not include adequate hydrologic analysis of the respective study areas that indicate critical low flow periods, or critical regions or basins. Also, the projections contained in those studies were of limited use in determining problem areas because they did not project monthly, or quarterly, consumptive uses of water but only indicated annual increases in streamflow depletions.

2) The power of eminent domain granted to municipalities and the relatively minor magnitude of municipal consumptive uses indicates that sufficient water will be available for urban growth.

3) Several regions in the Missouri and Yellowstone River basins do not have adequate water to supply all projected demands.

4) Water quality problems are present in several regions throughout Montana. They are attributable to both human practices and natural phenomena.

5) Instream reservation, Indian water rights, hydropower water rights, unadjudicated valid water rights throughout the state, and Canadian and Wyoming apportionments of inflows to Montana all contribute to the large amount of uncertainty that exists concerning the question of just how much water is available in Montana streams for future use.

6) In general, demands for all uses of water, instream and consumptive, are increasing.

7) The major form of competition for water use in the state is between instream and consumptive uses. The instream uses, maintenance of fisheries and riparian habitats, water quality control, and hydroelectric power generation, are effectively complimentary to one another. Water that remains instream for hydropower use is also useful for fisheries, and vice versa. The consumptive uses, irrigation, non-energy industrial use, and energy production, are competitive with one another and with instream uses. Instream reservation, for Indian rights, future beneficial uses, or federally reserved lands, are complementary with other instream uses so long as the water is not put to the intended use of the reservation. They are competitive with consumptive uses and become competitive with instream uses when put to a consumptive use, if that is the purpose for which the reservation is established.

8) The analysis in the previous sections leads to the conclusion that in most areas of the state unappropriated water is probably available for additional consumptive uses and that additional streamflow depletions are expected to occur.

Additional depletions reduce the value of instream uses which include hydropower, recreational use, water quality maintenance and the preservation of fish and wildlife habitat. Because consumptive users impose external costs on the beneficiaries of instream values and because irrigation, which is the principal consumptive use, is subsidized, consumptive uses and depletions will tend to exceed the optimal level of depletions that would result in the absence of subsidies and externalities. The central issue is the relative value of water for instream and consumptive uses and the allocation of flows between the competing uses. An evaluation of the impacts of water use on Montana's economic future should consider the contribution of consumptive uses and water resources investments on economic growth and development.

VIII. ECONOMIC IMPLICATIONS FOR MONTANA'S FUTURE

Considerable research has been done in the area of water availability and its impact on regional economic growth. Howe (1968), in a widely noted paper, used analysis of variance techniques to study whether water availability produced significant differences in the rate of economic growth among regions. He concluded that "water did not constitute a bottleneck to rapid economic growth in the water deficit areas of this country, nor did its presence in large quantities in other regions guarantee the rapid growth of these regions."

A more recent study by Cox, Grover, and Siskin (1971) examined the growth implications of large multi-purpose water projects in the northeastern United States. They concluded that "it is dubious whether water resources projects serve as a stimulus to economic growth for the strictly rural counties in the northeastern United States." Caution must be used in interpreting these conclusions and their implications for Montana, however, because of the limited geographic scope of the study. While Montana is relatively arid and sparsely populated, the northeastern United States receives a relative abundance of rainfall and is densely populated.

Rivkin/Carson, Incorporated (1973) under contract to the Department of the Interior, Bureau of Reclamation, performed a comprehensive study of water resource investments and their relationship to economic growth. The study area included Utah, Arizona, New Mexico, Colorado, and the southwestern corner of Wyoming. Twenty-one economic subregions were defined in the study area; political boundaries did not constitute economic boundaries. The study resulted in the following conclusions concerning economic growth and water resource investment projects:

> Previous research into the relationship between economic growth and investments in water resource projects concluded that (1) water deficiency does not constitute a barrier to economic development; (2) water resource development projects are likely to be poor tools for accelerating economic growth of rural counties; and (3) expenditures on water resource projects do not appear to affect population growth. These conclusions, based on the confined hypothesis that water by itself causes or stimulates regional economic growth, have not been invalidated by our further research.

> The present analysis has shown that water resource investments have an impact on economic growth depending on (1) the nature of the water investment; (2) the state of the regional economy, and (3) the amount and nature of other investments. p. 217

These conclusions do not imply that water resources investments produce no regional economic benefits, but that such benefits are less than has traditionally been assumed and that regional growth is not determined by isolated investments. The Rivkin-Carson study further concluded "that the regional development process relies for growth on a mix of public and private investments, rather than being determined by single major investments--whether in water, power, roads, manufacturing or other sectors."

The next issue considered is the impact on consumptive users of instream reservations that would limit the quantity of water available for additional depletion. The impacts of instream reservations on consumptive uses are very different and much less damaging if water rights are easily transferred among such users. The following discussion describes some impacts of a large instream reservation that would result if water rights can be easily rented or transferred.

A restriction on the quantity available for consumptive use will raise the value and transfer price of rights senior to the instream right. Anyone desiring a reliable right must purchase one because rights junior to the instream right are assumed to only be entitled to water in high flow years. New users must purchase rights instead of getting a free right and senior rights suddenly would find a valuable market for their right because free rights would no longer be available. The establishment of instream flows creates a windfall gain for owners of senior rights and imposes costs on new developers. Some low-valued uses such as irrigated pasture would revert to dryland operations and water would gradually be reallocated to the higher-valued uses which purchase water from the lower-valued uses. The net decrease in agricultural production would be the lost output of the operations which sold their water rights and accepted lower dryland yields.

If rights were not transferable new users would be unable to obtain water and the instream reservations would result in losses equal to the sum of value of the marginal product of water on all new uses denied rather than the value of the marginal product of the marginal uses.

Will limited water supplies in certain regions in the state seriously restrict agricultural growth without the construction of additional storage reservoirs? The information presented in this report indicates that this is not likely to be the case. There are abundant water rights presently appropriated for low-value agricultural uses. For example, unpublished DNRC data indicates that approximately 180,000 to 300,000 acres of pasture are currently irrigated in the Yellowstone River Basin. Transfers of water rights, even under the present administrative system, can accommodate large expansions in agricultural product values. However, adjudication of instream hydropower rights and Indian reserved rights may show that water available for new appropriations is limited, particularly in the Missouri River Basin.

Substantial instream reservations would increase water costs to the expanding energy industry but probably would have a minimal impact on siting decisions and output levels because water costs are a small portion of total costs for energy conversion plants and at any location sufficient water is available by storage or aqueduct at an affordable price.

Water is available by purchase from Yellowtail and Fort Peck reservoirs. Should Moorhead Dam be built and the Tongue River Reservoir developed for increased storage, water for industrial uses will be available by purchase from them as well. If the price of water becomes too high for generating plants to be willing to purchase it, then dry-cooling technologies can be used. Other alternative sources may include groundwater or water imported from Oahe Reservoir. The main point is that stored water is and will be available for industrial use, though perhaps at high prices which industry should be able to pay. If it cannot, then substitution will occur. The Wyodak thermal-electric generation plant in Wyoming is already in operation, using dry cooling. Attempts to legislate against industrial developments by limited access to a single input factor such as water is not likely to be successful, if other inputs, such as coal, are abundant and the demand for energy remains high.

It is suggested above that transferability of water rights can greatly limit the losses to consumptive uses that would result from a substantial instream reservation. Nevertheless an instream reservation is desirable only if the benefits to instream uses of such a reservation exceed the losses such a reservation would impose on the consumptive users. Methods for evaluating many of the benefits of instream flows are not adequate and an evaluation of the allocation of water between instream and consumptive uses is one of the remaining areas in need of further research.

IX. RECOMMENDATIONS FOR FURTHER RESEARCH

A decision of the Board of Natural Resources and Conservation on water reservation in the Yellowstone basin is likely to suddenly reduce the reliability of rights junior to the reservations. Research on the impacts of the reservation decisions is needed on the following topics.

1. A determination of the reliability of subsequent permits would be valuable. These could be made under alternative assumptions on the size of the unquantified Indian rights.

2. The implication of the reservation decision on water rights administration and enforcement need to be determined.

Irrigation water use accounts for 95 percent of all water use in Montana. Conservation of just a small percentage of the water normally used for irrigation could significantly increase the availability of water for other uses. Therefore, it would be desirable to research irrigation water conservation methods to consider the following items.

1. effects on current water shortage problems.
2. environmental impacts and benefits, especially instream flows.
3. water use efficiency of irrigation systems.

4. effects on the availability of water for irrigation and other uses.
5. the economic, legal, and institutional factors relating to irrigation water conservation.
6. present incentives for conservation or waste.
7. possible programs providing incentives for conservation and disincentives to waste.

LITERATURE CONSULTED

Angelidas. Sotirious. and E. Barkach. 1978. Water Banking: How to Stop Wasting Agricultural Water. Institute for Contemporary Studies. San Francisco, CA.

Butcher, Walter R., N.K. Whittlesey, and J.F. Orsborn. 1972 (May). Economic Value of Water in a Systems Contest. Pullman, WA.

Cicchetti, Charles J., V.K. Smith, and J. Carson. 1975 (February). "An Economic Analysis of Water Resource Investments and Regional Economic Growth." Water Resources Research. II (1): 1-6.

Cliff, C.B. and K.J. DeCook. 1975 (October). "Conflicts in Water Transfer from Irrigation to Municipal Use in Semiarid Environments." Water Resources Bulletin. II (5): 908-918.

Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council. 1966 (December). Water Resources and Economic Development of the West: Report No. 15. Las Vegas, NV.

Cox, Thomas P., C.W. Grover, and B. Siskin. 1971 (February). "Effect of Water Resource Investment on Economic Growth." Water Resources Research. 7 (1): 32-38.

Eckstein, Otto. 1965. Water Resource Development. Harvard University Press. Cambridge, MA.

Flack, John Ernest. 1965. Water Rights Transfers: An Engineering Approach. Stanford, CA. Stanford University, Institute of Engineering Economic Systems (EEEP-15, 1965). 49-63. Cited by L.D. James and R.R. Lee. Economics of Water Resource Planning. (McGraw-Hill, 1971). 315 pp.

Guise, J.W. and J.C. Flinn. 1970 (August). "The Allocation and Pricing of Water in a River Basin." American Journal of Agricultural Economics. 52 (3): 411-421.

Hartman, L.M. and D. Seastone. 1970. Water Transfers: Economic Efficiency and Alternative Institutions. Johns Hopkins Press. Baltimore, MD

Harza Engineering Company. 1976 (December). Analysis of Energy Projections and Implications for Resource Requirements. Harza Engineering Company. Chicago, IL.

Hirshleifer, J., J.A. DeHaven, and J.W. Milliman. 1960. Water Supply: Economics, Technology and Policy. Rand Corporation. Chicago, IL.

Howe, Charles H. 1968 (April). "Water Resources and Regional Economic Growth in the United States, 1950-1960." Southern Economic Journal. 34 (4): 477-499.

Howe, Charles H. and F.P. Linaweaver, Jr. 1967. "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure." Water Resources Research. 3 (1) (1st Qtr. 1976): 13-32.

International Souris Red River Engineering Board. Poplar River Task Force. 1976 (February). Poplar River Basin in Saskatchewan and Montana. Regina, Saskatchewan, Canada. Washington, D.C.

James, L.D. and R.R. Lee. 1971. Economics of Water Resources Planning. McGraw-Hill, Incorporated. New York, NY.

Lewis, W.C., J.C. Anderson, H.H. Fullerton, and B.D. Gardin. 1973. Regional Growth and Water Resource Investment. D.C. Heath and Company, Lexington, MA.

Missouri Basin Inter-Agency Committee. 1969 (June). The Missouri River Basin Comprehensive Framework Study, 1, 4, and 6. Washington, D.C.

Missouri River Basin Commission. 1978 (May). Yellowstone River Basin and Adjacent Coal Area Level B Study. 1-5. Omaha, NE.

________. 1977 (August). The Missouri River Basin Water Resources Plan. Omaha, NE.

Montana Department of Agriculture and Statistical Reporting Service-USDA. 1976. Montana Agricultural Statistics. XVI. Helena, MT.

Montana Department of Community Affairs. 1976. Montana Population Estimates 1950-1975. Division of Research and Information Systems. Helena, MT.

Montana Department of Fish and Game. 1978 (March). Montana Statewide Comprehensive Outdoor Recreation Plan. Helena, MT

Montana Department of Natural Resources and Conservation. 1975 (April). Water Resources Division. Water Use in Montana: Inventory Series Report No. 13. Helena, MT.

________. 1976 (October). Water Resources Division. The Framework Report. Volume I. Helena, MT.

________. 1976 (December). Yellowstone River Basin Draft Environmental Impact Statement for Water Reservation Applications, 1 and 2. Helena, MT.

________. 1976. Montana Water Rights - The Law - How it is Administered. Helena, MT.

________. 1977 (January). The Future of the Yellowstone River.....?, Helena, MT.

________. 1977 (January). Upper Flathead River Basin Study, Helena, MT.

________. 1977 (February). Supplemental Water for the Milk River. Helena, MT.

________. 1977 (July). "The Effect of Altered Streamflow on Fish of the Yellowstone and Tongue Rivers Montana." Yellowstone Impact Study Technical Report No. 8. Helena, MT.

________. 1978 (April). Water Uses in the Poplar River Basin Final Report. Helena, MT.

Montana Department of Natural Resources and Conservation and the Pacific Northwest River Basin Commission. 1976 (September). The Flathead River Basin Level B Study of Water and Related Lands. Helena, MT.

Montana Department of Natural Resources and Conservation and the Cooperative Extension Service, Montana State University. 1976. Water Rights Adjudication - How the Process Works. Helena, MT.

Montana University Coal Demand Study Team. 1976 (May). Projections of Northern Great Plains Coal Mining and Energy Conversion Development: 1975-2000 A.D. Missoula, MT: University of Montana and Bozeman, MT: Montana State University.

Native American Natural Resources Development Federation of the Northern Great Plains. 1977 (June). "Declaration of Indian Rights to the Natural Resources in the Northern Great Plains States."

Northern Great Plains Resource Program. 1974 (December). Report of the Work Group on Water.

Northwest Resource Program Group, Natural Resource Economic Division, Economic Research Service, U.S. Department of Agriculture. 1975 (January). The Economic Base of the Clark Fork of the Columbia River Basin, Montana, With Preliminary Projections to 1980, 2000 and 2020. Corvallis, OR.

Oeltjen, Jarrett C. and L.K. Fisher. 1978. "Allocation of Rights to Water: Preferences, Priorities and Role of the Market: Nebraska Law Review. 57 (2): 248-277.

Pacific Northwest River Basins Commission. 1972 (September). Columbia-North Pacific Region Comprehensive Framework Study of Water and Related Lands: Main Report and Appendices V, VI, IX, XI, and XV. Vancouver, WA.

Rarick, Joseph F. 1970 (February). "Oklahoma Water Law, Stream and Surface Under the 1963 Amendments." Oklahoma Law Review. 23: (1).

Rivkin/Carson, Incorporated. 1973. Economic Development and Water Resource Investments. Washington, D.C.

Stroup, R.L. and S.B. Townsend. 1974. "Water Use and Coal Development in Eastern Montana: Water Availability and Demands," Montana University Joint Water Resources Research Center, Bozeman, MT

Stroup, Richard L. 1976. "The Economics of Competing Water Use in the Northern Great Plains," Montana State University Department of Agricultural Economics and Economics. Staff Paper 76-8.

Trelease, Frank J. 1974 (April). "The Model Water Code, the Wise Administrator and the Goddam Bureaucrat." Natural Resources Journal. 14: 207-229.

U.S. Department of Agriculture. Bureau of Reclamation. 1977 (January). "Preliminary Issue Paper: Yellowstone River Basin and Adjacent Coal Area Level B Study."

_________. 1977. Supplemental Water for the Milk River.

U.S. Department of Agriculture, Soil Conservation Service, and Montana Department of Natural Resources and Conservation. 1977. Clark Fork of the Columbia River Basin Cooperative Study. Portland, OR.

U.S. Department of Interior Water for Energy Management Team. 1974 (October). Report on Water for Energy in the Northern Great Plains Area with Emphasis on the Yellowstone River Basin. Denver, CO.

U.S. Geological Survey. Water Resources Division. 1976 (August). Water Resources Data for Montana, 1975. Helena, MT.

U.S. Water Resources Council. 1972. OBERS Projections: Volume I Concepts, Methodology and Summary Data. Washington, D.C.

Veeder, W. H. 1975. "Confiscation of Indian Winters Rights in the Upper Missouri River Basin." Testimony before the subcommittee on Energy Research and Water Resources of the Committee on Interior and Insular Affairs, United States Senate. July 18, 1975.

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